

MAKERERE



UNIVERSITY

**COLLEGE OF HEALTH SCIENCES
SCHOOL OF MEDICINE
DEPARTMENT OF ORTHOPEDIC SURGERY**

**PREVALENCE AND FACTORS ASSOCIATED WITH LIMB LENGTH
DISCREPANCY FOLLOWING INTRAMEDULLARY NAILING OF FEMUR SHAFT
FRACTURES IN ADULTS AT MULAGO NATIONAL REFERRAL HOSPITAL**

BY

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DECLARATION

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DEDICATION

I dedicate this work to my wife and children, for their understanding and patience while I was away working on this project.

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ACRONYMS

AO/OTA	:	Arbeitsgemeinschaft für Osteosynthesefragen/ Orthopaedic Trauma Association
ASA	:	American Society of Anesthesiologists
CT	:	Computed Tomography
IMN	:	Intramedullary Nailing
IRB	:	Institutional Review Board
LLD	:	Limb Length Discrepancy
MNRH	:	Mulago National Referral Hospital
MRI	:	Magnetic Resonance Imaging
PI	:	Principal Investigator

OPERATIONAL DEFINITIONS

Associated factors	This referred to patient-related (age, mid-thigh circumference), surgical factors; (nail entry, locking mode, fluoroscopy, pre-operative traction) or injury related variables (mechanism of injury, fracture location, pattern, time to surgery, that are likely to cause limb length discrepancy
IM nailing	This referred to the surgical fixation of femoral fractures using an inter-locking intramedullary nail.
Limb Length Discrepancy:	This was defined as a measurable radiological difference in the femur lengths of the operated limb in comparison to the non-operated/normal.
Mild LLD:	This referred to limb length discrepancy that was < 2 centimeters between the injured limb compared to the normal limb
Moderate LLD:	This referred to limb length discrepancy that was between 2-5cm between the injured limb compared to the normal limb
Severe LLD:	This referred to limb length discrepancy > 5 centimeters between the injured limb compared to the normal limb
Fracture pattern:	This was the configuration of the fracture line and fragments in a broken femur bone classified using AO classification.

ABSTRACT

Background. Limb length discrepancy (LLD) is a recognized complication following intramedullary nailing (IMN) of femoral shaft fractures, with a reported global incidence of 20–43%. In sub-Saharan Africa, limited access to intraoperative imaging, and fracture table heights this risk. In Uganda, the burden of LLD following IMN remains poorly characterized, creating an evidence gap. Complications such as gait disturbance, early arthritis and psychological distress may occur in patients with LLD.

Objectives. The objective of this study was to determine the prevalence of LLD and to identify the factors associated with LLD following IMN of femoral shaft fractures among adults at Mulago National Referral Hospital (MNRH), Kampala, Uganda.

Methods. An analytical cross-sectional study was conducted at Mulago National Referral Hospital from October 2025 to February 2026. 101 consecutive adult patients (≥ 18 years) who had undergone IMN for femur shaft fractures were enrolled on their first post-operative day. Limb length was measured radiologically using CT-scanogram. LLD was categorized as mild LLD (< 2 cm), moderate (2–5 cm), or severe (> 5 cm). Ordinal logistic regression adjusted for clustering at the surgical team level was used for bivariate and multivariable analysis in STATA version 15.

Results. The overall prevalence of LLD was 38.6% [95% CI (29.1,49.8)], 23.8% [95% CI (15.9,33.3)] had mild LLD and 14.8% [95% CI (8.6,23.3)] had moderate LLD; In multivariable ordinal logistic regression, greater trochanter nail entry (aOR 2.79, 95% CI 1.99,3.90, $p < 0.001$), absence of pre-operative traction (aOR 3.96, 95% CI 3.04,5.17, $p < 0.001$), comminuted fractures with (aOR 13.62, 95% CI 2.14,86.74, $p = 0.006$), Fracture location (mid-third aOR 0.21; distal aOR 0.12, both $p < 0.001$), Mid-thigh circumference (aOR 1.11, 95% CI 1.07,1.14, $p < 0.001$), were independently associated with LLD. Surgical delay was strongly associated with worse LLD in bivariate analysis (OR 84.00, 95% CI 21.73,324.64, $p < 0.001$) though model instability due to sparse data. precluded its inclusion in the final multivariable model.

Conclusions. LLD is a complication following femur fractures after IMN at MNRH, affecting 38.6% of patients on the first post-operative day. Complex fracture patterns, absence of pre-operative traction, and greater trochanter nail entry were independently associated with LLD. Reducing time to surgery, standardizing pre-operative traction for all patients awaiting IMN, and improving access to intraoperative fluoroscopy are the most actionable interventions to reduce the LLD burden at this institution.

CHAPTER ONE

INTRODUCTION

1.1 Background

Limb length discrepancy (LLD) is a complication that arises following intramedullary nailing (IMN) of femur fractures, with a global incidence of approximately 20-43% (Ian Hudson et al., 2019). In Africa, a study by Phiri et al. (2018) conducted in Zambia Lusaka reported an LLD incidence of 35.3% post IMN.

In East Africa, the orthopedic landscape faces similar challenges. Reviews highlight an increasing burden of musculoskeletal disorders, including complications from fractures, with LLD emerging as a significant concern (Makhni et al., 2019). Limited access to advanced surgical facilities and specialized training in the region often exacerbates the risk of complications, such as LLD, following IMN.

In Uganda, anecdotal evidence points to a rising incidence of LLD among adults treated with IMN for diaphyseal femur fractures. This trend may be attributed to the lack of modern techniques and resources to mitigate LLD in local healthcare settings. While the AO Foundation recommends IMN as a preferred surgical technique for treating diaphyseal femur fractures in adults due to its effectiveness in restoring length, alignment, rotation, and angulation, cases of LLD persist despite its advantages.

Several factors are thought to contribute to LLD in this patient population, including delayed surgery, fracture characteristics, and mechanisms of injury which are mostly road traffic accidents which are high energy injuries causing complex fracture patterns. Uncorrected, significant LLD can lead to gait abnormalities, joint degeneration, and chronic pain and need of additional corrective surgery. Given the scarcity of advanced equipment such as traction tables, traction devices such as femoral distractors, intra-operative imaging and techniques to address LLD in our setting, this study aimed at evaluating the prevalence and associated factors of LLD among adults with femur fractures who had been managed with IMN. The findings could offer valuable insights for improving surgical practices and patient outcomes.

1.2 Problem statement

Limb length discrepancy (LLD) is one of the complications of femur fractures. This can arise after fixation of the femur fracture using an intramedullary nail (IMN), with a global incidence ranging from 20% to 43% (Ian Hudson et al., 2019). The impact of LLD on patients can be profound, varying in severity but often leading to significant physical and emotional challenges. Mobility difficulties, chronic arthritis and reduced quality of life are frequent outcomes, and in severe cases, psychological distress may occur (Kakadia et al., 2019).

Femur fractures are one of the commonest fractures of long bones in MNRH with a prevalence of 20.9%. (Kironde et al, 2019.) These are one of the most operated fractures in MNRH since it's the main stay of treatment in adults.

Several factors may contribute to LLD in our setting, including the prolonged time to surgery following injury due to unavailable implants, traditional bone setters where some of our patients with femur fractures first seek care, high patient load with inadequate infrastructure all of which lead to delayed operation. Fracture pattern, not using equipment such as traction table and fluoroscopy. Given these challenges, this study aimed at determining the prevalence of LLD and identifying the associated factors in adults treated with IMN for femur fractures at MNRH. Understanding these factors will guide improvements in patient care and surgical outcomes.

A pilot study conducted in the orthopedic department at Mulago National Referral Hospital (MNRH) from August to November 2024 on patients at the Orthopedic wards on the first post operative day revealed that among the 95 patients treated with IMN for femur fractures, 18.7% (17 patients) presented with an LLD exceeding 2 cm. Of these, 12 patients had an LLD between 4–6 cm. Some of these needed additional corrective surgeries for limb lengthening while others were offered orthotics such as shoe raise to correct the LLD.

It's against this background that we aimed to study prevalence and factors associated with LLD among adults with femur shaft fractures at Mulago National Referral Hospital.

1.3 Justification

Limb length discrepancy (LLD) can lead to significant complications, including abnormal gait patterns, early onset of degenerative joint changes, and potential legal challenges due to poor surgical outcomes. Addressing LLD during surgical fixation is therefore crucial to improving patient outcomes and reducing these complications.

This study aimed to establish the burden of LLD and associated factors and thus highlight the need for prioritizing the acquisition of appropriate equipment such as traction devices, fluoroscopy minimizing LLD during surgery. The findings will serve as a foundation for developing future management protocols for diaphyseal femur fracture management and provide valuable insights to guide further research in this area. By addressing the gaps, the study sought to enhance both surgical practices and care for patients.

1.4 Research questions

1. What is the prevalence of limb length discrepancy (LLD) following intramedullary nailing (IMN) of femur fractures among adults at Mulago National Referral Hospital?
2. What are the factors associated with limb length discrepancy (LLD) following intramedullary nailing (IMN) of femur fractures among adults at Mulago National Referral Hospital?

1.5 Objectives

1.5.1 General objective

To establish the prevalence of limb length discrepancy (LLD) and identify the factors associated with LLD following intramedullary nailing (IMN) of femur fractures among adults at Mulago National Referral Hospital.

1.5.2 Specific objectives

1. To determine the prevalence of limb length discrepancy (LLD) following intramedullary nailing (IMN) of femur fractures among adults at Mulago National Referral Hospital.
2. To establish the factors associated with limb length discrepancy (LLD) following intramedullary nailing (IMN) of femur fractures among adults at Mulago National Referral Hospital.

1.6 Significance

Prevention of LLD is crucial, as this can prevent patient morbidity and the need for more invasive surgical procedures associated with correction of LLD, which often carries increased morbidity.

This study holds both direct and indirect significance for orthopedic care and public health. Directly, it aimed at enhancing clinical practice at the department of orthopedics, Mulago National Referral Hospital by establishing the prevalence of leg length discrepancy (LLD) following intramedullary nailing (IMN) and identifying associated risk factors.

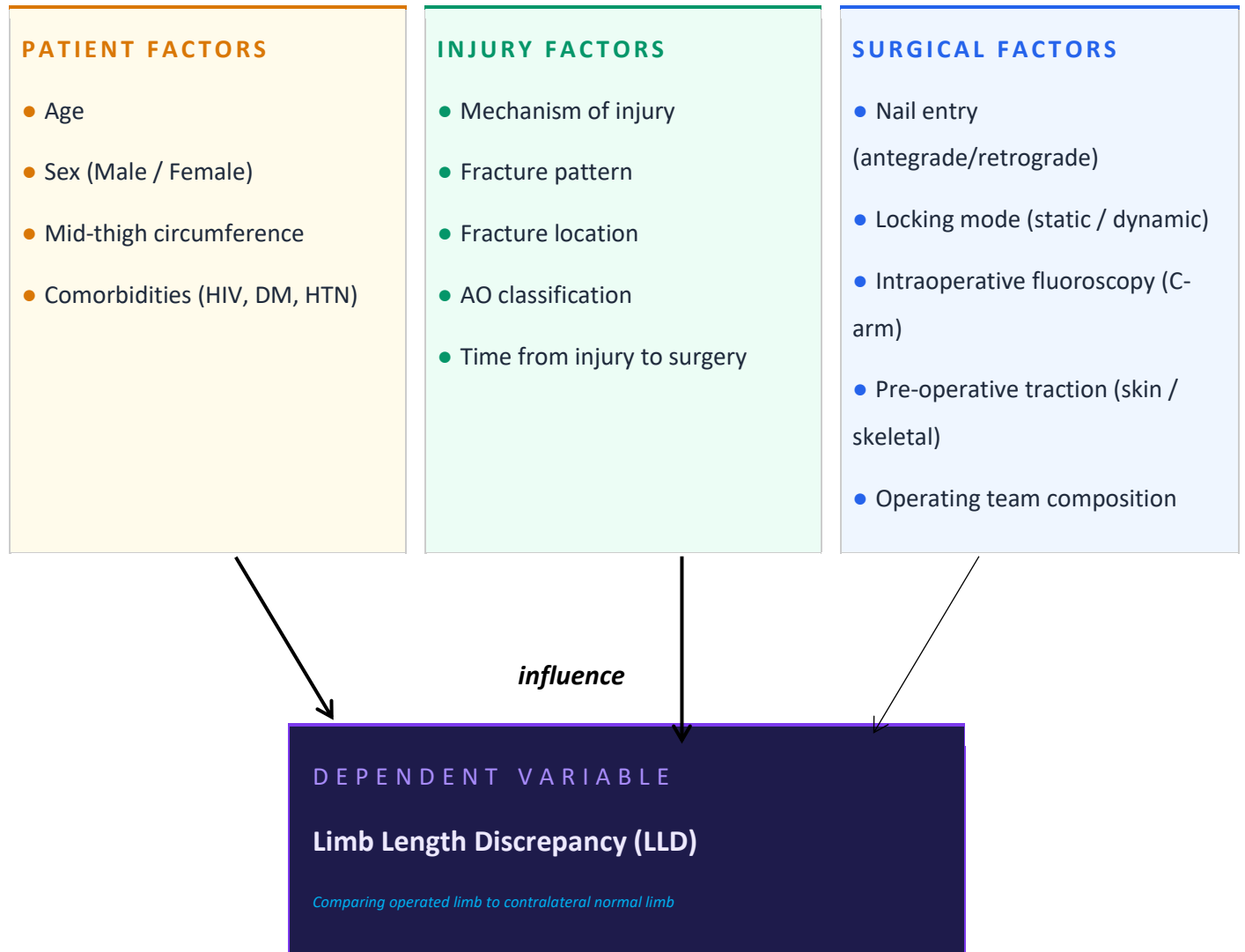
This study aimed at highlighting the burden of LLD and associated factors. This will highlight the need for prioritizing the acquisition of appropriate equipment to minimize LLD during surgery.

Indirectly, the study raises awareness of LLD's potential consequences, encouraging preventive measures and improved surgical practices within the healthcare system.

Participants found to have LLD were informed and the primary surgeon who decided on the plan helping to avoid complications such as arthritis and chronic pain. The study will enable clinicians to recognize high-risk patients pre-operatively and implement targeted intraoperative measures to mitigate discrepancy. The findings may also inspire further research, influence training programs for medical professionals, and contribute to global discussions on orthopedic management in low-resource settings.

1.7 Conceptual Framework

– INDEPENDENT VARIABLES –



This conceptual framework was designed to provide a comprehensive analysis of LLD following IMN of femur fractures. It categorized the independent variables into patient factors, injury-related factors and surgery related factors systematically relating them to the dependent variable. Despite existing debates in the literature regarding the association between these factors and LLD, we hypothesized that these factors do not influence the occurrence of LLD following surgery. Consequently, our study aimed at portraying the relationship between these factors and the occurrence of LLD.

1.8 Study scope

The study was designed to comprehensively assess the prevalence and associated factors of limb length discrepancy following intramedullary nailing of femur fractures among adults at Mulago National Referral Hospital.

It systematically evaluated demographic, injury, and surgical factors among adult patients who had undergone IMN, using CT-scanogram done on the first post operative day. The findings are expected to inform clinical practice, surgical training, and resource allocation to improve orthopedic care and patient outcomes in Uganda.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter aims to explore the existing body of research surrounding leg length discrepancy (LLD) following intramedullary nailing (IMN) of femur fractures. This chapter will highlight key findings from studies conducted globally, regionally, and locally, focusing on the prevalence, risk factors, and outcomes associated with LLD in patients undergoing IMN.

By synthesizing current knowledge, this review will provide a foundation for understanding the significance of LLD as a complication in orthopedic surgery, the implications for patient quality of life, and the need for prevention measures in the Ugandan healthcare context.

2.1 Prevalence of Leg Length Discrepancy (LLD)

Leg length discrepancy (LLD) following intramedullary nailing (IMN) of femur fractures is a well-documented complication. Studies indicate a global incidence rate of LLD ranging from 20% to 43%, depending on various factors, including surgical technique and patient demographics (Ian Hudson et al., 2019). In Zambia Lusaka, a study found that approximately 35% of patients experienced significant LLD post-surgery, highlighting the regional challenges faced in managing femur fractures (Phiri et al., 2018). Limited data from Uganda further underscores the need for local research to understand the specific prevalence of LLD in this population, as existing literature lacks comprehensive studies on the topic.

Research conducted in other regions has also shed light on the prevalence of LLD following femur fractures treated with IMN. In a large multicenter study in the United States, it was reported that 18% of patients experienced clinically significant LLD post-surgery (Kakadia et al., 2019). This discrepancy illustrates that while the phenomenon is recognized globally, the rates can vary significantly based on geographical, clinical, and methodological factors. In Europe, studies have shown prevalence rates ranging from 12% to 25%, indicating a need for further exploration of the variables affecting these outcomes, such as variations in surgical practices, postoperative rehabilitation protocols, and patient populations (Vaidya et al., 2019).

The impact of surgical technique on LLD prevalence cannot be overlooked. Variations in the insertion angle of the intramedullary nail, the choice of nail type, and the adequacy of fracture

reduction can all affect the risk of developing LLD. Some studies have suggested that using a reamed intramedullary nail compared to an unreamed nail may result in lower rates of LLD, though results are not universally agreed upon (Raza et al., 2021). Thus, ongoing training and standardization of surgical techniques may be crucial for improving outcomes.

The implications of LLD extend beyond physical health, affecting patients' psychological well-being and quality of life. Studies have shown that individuals with LLD may experience not only physical discomfort but also emotional distress, reduced self-esteem, and limitations in daily activities (Makhni et al., 2019). These factors highlight the importance of addressing LLD not merely as a surgical complication but as a significant public health concern that can impact patients' overall well-being.

Limb length discrepancy can be classified basing on the severity of the discrepancy and according to the international center of limb lengthening at the Rubin institute in USA this was classified basing on the severity and the desired intervention for the discrepancy.

Category	Definition	Outcome
No LLD	No measurable discrepancy	Optimal outcome
Mild LLD	< 2 cm difference	May not require intervention
Moderate LLD	2 – 5 cm difference	Functional impact; often needs treatment
Severe LLD	> 5 cm difference	Major functional impairment

2.2 Factors Associated with LLD

Several risk factors have been identified that contribute to the development of LLD after IMN. According to Winquist and Hansen (1984), higher degrees of fracture comminution correlate with an increased incidence of LLD, particularly in complex fractures categorized as types III

and IV. Additionally, patient-specific factors such as age, gender, and pre-existing conditions may influence outcomes. A study by Vaidya et al. (2019) recommended that discrepancies greater than 20 mm should be corrected, indicating that not all cases of LLD may require surgical intervention. Understanding these factors is crucial for developing targeted strategies to mitigate the risk of LLD in patients undergoing IMN.

Mechanism of injury has also attributed to the occurrence of LLD. High energy injuries such as gunshot wounds and motor vehicle accidents which have a direct impact on the fracture pattern leading to severe comminution and thus making apposition of the ends difficult leading to LLD in many of the patients Petra et al (2018).

Fracture characteristics play a significant role in determining LLD outcomes. Complex fractures, which typically involve multiple fracture lines and extensive soft tissue injury, pose a higher risk for complications such as malalignment and nonunion. These complications can arise due to inadequate stabilization during the surgical procedure, leading to imprecise healing and eventual discrepancies in limb length. Moreover, the surgical technique employed, including the alignment of the intramedullary nail and the adequacy of reduction, directly impacts the likelihood of achieving optimal outcomes. Variability in surgical expertise and experience among orthopedic surgeons may also contribute to inconsistencies in LLD rates, underscoring the need for standardized protocols in fracture management (Raza et al., 2021).

Delayed surgery is one of the commonest risk factors to acquiring LLD after IMN of femur fractures. Ashock et al (2010) found out that patients who have surgery more than 2 months from the time of injury had some complications such as delayed union and all of these had come degree of shortening.

Delayed surgical intervention, common in these resource limited settings, contributes to difficulties in achieving proper fracture reduction, leading to misalignment and LLD. Many patients face delays in accessing care due to financial constraints and long travel distances to healthcare facilities. Jayasuriya A et al 2016.

Patient demographics, particularly age, have been linked to LLD outcomes. Older adults often present with more complex fractures due to decreased bone density and increased fragility. This demographic may also experience slower healing rates and a greater likelihood of postoperative

complications, including LLD (Makhni et al., 2019). Additionally, the presence of comorbid conditions such as diabetes and osteoporosis can further complicate recovery and increase the risk of LLD, highlighting the importance of preoperative assessments that take these factors into account. Identifying at-risk populations allows for tailored surgical planning and postoperative management strategies aimed at minimizing the potential for LLD.

Gender differences may also influence LLD outcomes, as studies have indicated variations in bone structure and healing responses between men and women. For instance, some research suggests that female patients may have a higher incidence of LLD due to anatomical differences in femoral morphology, which can affect surgical alignment during IMN (Chuma et al., 2020). Understanding these gender-specific nuances is essential for refining surgical techniques and rehabilitation approaches to address the unique needs of different patient groups.

The surgical technique itself is a critical factor in the development of LLD. The insertion angle of the intramedullary nail and the choice between reamed and unreamed nails have been shown to affect outcomes. Reamed nails, which involve the preparation of the intramedullary canal before nail insertion, may allow for better alignment and stabilization, potentially reducing the risk of LLD (Kakadia et al., 2019). Conversely, unreamed nails may lead to inadequate fixation and increased risk of malalignment. Furthermore, variations in nail length and diameter can also play a role in the final leg length, emphasizing the need for careful selection based on individual patient anatomy.

Postoperative rehabilitation and monitoring are vital components that can influence the risk of LLD. Effective rehabilitation programs that focus on restoring mobility and proper limb alignment can help mitigate the development of LLD. Regular follow-up appointments are essential for monitoring leg lengths through radiographic assessments, allowing for the early identification of discrepancies and timely interventions. This proactive approach can prevent the need for more invasive corrective surgeries later on, which often come with higher risks and morbidity (Vaidya et al., 2019).

Operating on femoral shaft fractures in obese patients is technically demanding because excess soft tissue makes it difficult to identify bony landmarks and obtain an accurate starting point for antegrade intramedullary nailing, which translates into significantly longer operative times and greater fluoroscopic exposure compared with non-obese patients. In Tucker et al, 2017's

multicenter study, antegrade nailing in obese patients took about 50% longer and required roughly 80% more radiation time than in non-obese patients, reflecting the added complexity of positioning, reduction, and imaging through a large soft-tissue envelope which can lead to LLD

2.3 Consequences of LLD

The consequences of LLD can be significant and multifaceted. Patients with LLD may experience gait abnormalities, joint pain, and increased risk of degenerative conditions, which can severely impact their quality of life (Kakadia et al., 2019). Research has shown that even a minor discrepancy of 10 mm can lead to postural instability and increased risk of falls (Raza et al., 2021). Furthermore, LLD can have psychological implications, leading to diminished self-esteem and social withdrawal. Understanding these consequences emphasizes the importance of early detection and intervention strategies to improve overall patient outcomes.

The physical consequences of LLD extend beyond immediate mobility issues. Over time, chronic joint pain and biomechanical imbalances can lead to secondary complications, including lumbar spine pain and hip or knee osteoarthritis, significantly diminishing the patient's quality of life (Makhni et al., 2019). The cumulative effect of these conditions can create a cycle of decreased physical activity and worsening health outcomes, further exacerbating the initial issue of LLD. Therefore, understanding the long-term implications of untreated LLD is crucial for both patients and healthcare providers, as it underscores the need for timely interventions.

Moreover, LLD can have profound psychological implications. Patients often report diminished self-esteem, anxiety, and depression related to their altered physical appearance and functional limitations. The societal stigma associated with visible discrepancies can lead to social withdrawal and isolation, significantly impacting mental health and overall well-being (Chuma et al., 2020). The psychological burden of living with LLD can further complicate the recovery process, as emotional health is closely linked to physical rehabilitation outcomes. This aspect highlights the importance of a holistic approach to treatment, addressing not only the physical but also the emotional and psychological needs of patients.

In addition to personal implications, LLD can impose broader social and economic burdens. Patients may require additional medical attention, including ongoing physical therapy, orthotic devices, or even corrective surgery, which can result in increased healthcare costs and loss of

productivity (Vaidya et al., 2019). The need for long-term management of LLD-related complications can strain healthcare systems, particularly in low-resource settings where access to orthopedic care may be limited.

Early detection and intervention strategies are essential to mitigate these consequences and improve overall patient outcomes. Regular monitoring of limb lengths following surgical intervention can facilitate the timely identification of discrepancies, allowing for corrective measures to be implemented before significant complications arise. Additionally, patient education on the signs and symptoms of LLD can empower individuals to seek medical attention sooner, thereby reducing the long-term impact of the condition.

2.4 Management and Interventions

Effective management of LLD requires a multidisciplinary approach that includes early detection, surgical intervention, and rehabilitation. Current literature suggests that timely correction of LLD can significantly improve patient outcomes (Vaidya et al., 2019). Studies recommend regular follow-ups post-surgery to monitor LLD and address any discrepancies promptly. Additionally, training for orthopedic surgeons in recognizing and managing LLD could enhance surgical practices and minimize complications. As highlighted by Makhni et al. (2019), implementing standardized protocols for assessing and correcting LLD is essential for improving care quality in orthopedic settings, particularly in regions with high incidences of femur fractures.

Intra-operative measurement of correction following recognition of LLD in patients treated with locked femoral IMN requires precise methods. Often the nail diameter as a reference gauge on the fluoroscopic image and lengthen or shorten the distracter as needed. Two other techniques have proved useful during the corrective procedure. One is to leave a locking screw partially removed on the outer cortex to help determine the change in length that has been achieved. The surgeon can then measure the distance from the screw to the locking hole or the distal tip of the nail. Another option is to place a k-wire or the distracter pin in line with the tip of nail and lengthen or shorten relative to this mark. Despite these techniques, it is still not an easy or perfectly accurate endeavor. Rahul et al 2012

Postoperative monitoring should include systematic assessments of limb lengths through radiographic evaluations and clinical examinations. Studies indicate that utilizing standardized measurement techniques can enhance the accuracy of detecting LLD and improve overall management practices (Makhni et al., 2019). This standardization is particularly vital in settings where variations in surgical techniques and patient demographics may impact outcomes. Training orthopedic surgeons in recognizing the early signs of LLD and understanding the implications of various surgical approaches can also minimize complications. By fostering an environment of continual learning and adaptation, healthcare professionals can improve the quality of care provided to patients at risk for LLD.

In terms of surgical intervention, research highlights the importance of addressing significant discrepancies as soon as they are identified. For discrepancies greater than 20 mm, surgical correction is generally recommended, as these can lead to considerable functional impairments (Vaidya et al., 2019). Various surgical techniques are available, including lengthening procedures, osteotomies, and the use of prosthetic devices. The choice of intervention should be individualized based on the patient's specific condition, age, and overall health status. By tailoring the approach to the patient's needs, healthcare providers can optimize surgical outcomes and minimize risks.

Femoral reconstruction with an osteotomy around an existing intramedullary nail was introduced to address axial deformity correction and limb lengthening without changing or removing a previously inserted IMN. This technique uses the principles of lengthening over an IMN. The presence of the nail has minimized the time needed for the external fixator because the nail supports the regenerate bone or osteotomy during the consolidation phase. With this technique, surgery is minimized by avoiding the need for exchange nailing. (Han et al 2011)

Rehabilitation plays a critical role in the management of LLD. Comprehensive rehabilitation programs should focus on restoring mobility, strength, and functionality. Physical therapy can help patients adapt to any discrepancies while improving their overall biomechanics and reducing the risk of secondary complications. Therapists can implement exercises designed to enhance stability and strength, aiding in compensatory mechanisms that the body may adopt due to LLD. Educational components, such as training patients on proper gait mechanics and strengthening exercises, can empower individuals to take an active role in their recovery.

Moreover, the psychological aspects of LLD management must not be overlooked. Counseling services or support groups can provide valuable resources for patients coping with the emotional ramifications of living with LLD. Addressing mental health is essential for improving overall treatment outcomes and enhancing patients' quality of life. Integrating mental health support into rehabilitation programs can lead to better adherence to treatment plans and improved functional outcomes.

Implementing standardized protocols for assessing and correcting LLD is also essential for improving care quality in orthopedic settings, particularly in regions with high incidences of femur fractures (Makhni et al., 2019). These protocols can ensure consistency in how LLD is monitored, assessed, and managed across different healthcare settings. Establishing clear guidelines can help reduce variability in practice and enhance overall patient care.

In conclusion, managing leg length discrepancy following intramedullary nailing of femur fractures necessitates a comprehensive, multidisciplinary approach. From early detection and timely surgical interventions to robust rehabilitation and psychological support, each element plays a vital role in improving patient outcomes.

2.5 Methods for assessing LLD

Numerous methods have been described to assess limb length including a clinical examination and imaging modalities that comprise plain radiography, computed radiography, micro-dose digital radiography, ultrasonography, computerised tomography (CT) and magnetic resonance and imaging (MRI). A recent report has highlighted the high accuracy and reliability of a CT scanogram in limb length measurements. Further, CT scanogram has been reported to have comparable costs as plain radiographs with less gonadal radiation. (Rahul et al)

CT scanogram is the standard for measuring postoperative femur length. It offers the advantage of delivering a fraction of the radiation dose delivered by orthoroentgenograms with comparable cost. Moreover, the radiation with the CT scanogram is about 80% less than that delivered during the orthoroentgenogram. Further, CT scanograms have been found to be more accurate than orthoroentgenography in determining the total leg length when the knee is flexed. A CT scanogram can also be enlarged to make the measurement easier and perhaps more accurate. (Rahul et al)

The use of blocks under the short leg to level the pelvis has been shown to be the most reliable clinical test for LLD. Jonson and Gross examined intraobserver and interobserver variability in LLD assessment using blocks to level the pelvis.

Micheal et al suggest that the interobserver reliability of all three methods of clinical LLD assessment (ASIS to medial malleolus, ICC = 0.83; ASIS to lateral malleolus, ICC = 0.80; block measurement, ICC = 0.83) was similar. However, the 95% confidence interval was smaller for block measurements compared with the other clinical measurements using a tape measure from the ASIS. The 95% confidence interval for interobserver measurement of LLD using blocks measured 2.2 cm in our study. This large 95% confidence interval is unacceptable for clinical decision making, and these results confirm the observation by Green et al that clinical measurement of LLD may be grossly inaccurate.

The reliability of orthoroentgenograms and CT scanograms has been extensively studied, and in the absence of flexion contractures they have similar reliability and accuracy. Some of the advantages of CT scanogram over orthoroentgenogram shown by these studies are decreased radiation and better assessment of limb length in the setting of flexion deformity.

Computerized tomography scano-gram (CT-scanogram) utilizing a single anteroposterior (AP) scout film over the pelvis and entire lower limbs is a modality to measure LLD. The accuracy and interobserver reliability and intraobserver reproducibility of CT-scanogram have been evaluated by previous studies and were found to be very high. These factors make CT-scanogram a reliable method to measure LLD, and it can be used as a reference method to which other methods can be compared. (Martin et al)

Sabharwal et al. compared clinical tape measurements with scanogram measurements in a patient cohort, finding that radiological methods provided a more reliable quantification of LLD. The study emphasized that while clinical methods are accessible, they are subject to measurement errors due to patient positioning and soft tissue interference.

The evaluation of leg length discrepancy has been made radiologically for several decades using a technique called orthoroentgenology. With this technique three exposures of the lower extremities (centering over the hips, knees, and ankles in turn) are made on a single film with a radiopaque ruler placed between the legs at about the height of the bone to avoid magnification.

Measurements of each femur and tibia are then made by extending a right angle from the ruler to the bony site to be measured. This technique, although widely used, is cumbersome, tedious, and delivers moderate radiation to a predominantly young population. Digitized radiographs obtained with a CT scanner (GE Scoutview) can be easily utilized for standard measurement of body parts as has been demonstrated by CT pelvimetry. These measurements are fast, accurate, and entail low radiation exposure. When this technique is applied to scanograms of the legs and found it to be superior to the conventional technique. (Clyde et al)

2.6 Hypothesis

There is **no significant association** between patient-related, injury-related, and surgery-related factors and the occurrence of limb length discrepancy (LLD) following intramedullary nailing (IMN) of femur fractures among adults at Mulago National Referral Hospital.

CHAPTER THREE

METHODS

3.1 Study design

This was an analytical cross-sectional study.

3.2 Study site

The study was conducted at MNRH in Kampala, Uganda. This hospital was established in 1913 and as the primary national referral hospital, MNRH provides specialized healthcare services, training opportunities, and research activities in line with the Ministry of Health's objectives. It serves as a teaching institution for Makerere College of Health Sciences and other health science schools, significantly contributing to the education of healthcare professionals. The hospital is conveniently located approximately 4.7 kilometers from the main post office in Kampala, facilitating prompt management of patients with musculoskeletal injuries.

Mulago National Referral Hospital receives most of the trauma patients around Kampala and the neighboring districts because it's a national referral hospital and easily accessible.

The Orthopedics Department at MNRH features four dedicated inpatient wards—Trauma Ward, Ward 7, Arthroplasty Ward, and Spine Ward as well as an outpatient clinic that operates Monday to Thursday. These wards admit patients with various injuries including femur fractures. Ward 7, trauma ward are in the old Mulago and majority of the patients with fractures are admitted there. Each of these has designated preoperative and post-operative beds where the patients are put from zero post operative day.

These wards are well equipped with trolleys and wheelchairs for transporting patients for various investigations.

Mulago National Referral Hospital is particularly well-suited for studying limb length discrepancy (LLD) due to its experience in managing complex orthopedic cases and its investigative capacity. The Orthopedics Department handles a significant volume of femur fractures, providing ample opportunities to evaluate post-surgical outcomes, including LLD. With a dedicated team of orthopedic surgeons, residents, and specialized nursing staff, MNRH is equipped to implement standardized protocols for monitoring and managing LLD.

Additionally, the presence of an outpatient clinic allows for ongoing follow-up assessments, enabling timely identification and intervention for patients at risk of developing complications associated with LLD.

3.3 Populations

Target population

The target population for this study included all adult patients with fractures in Uganda.

Accessible population

The accessible population consisted of all adult patients with femur fractures at MNRH during the study period.

Study population

The study population consisted of all adult patients at MNRH who were treated with interlocking IMN after femur fracture at MNRH who were on the first post-operative day, met the eligibility criteria and consented for the study

3.4 Eligibility criteria

3.4.1 Inclusion criteria

Any patient at least 18years who was treated with IMN after femur fracture and was on the first post-operative day and consented for the study.

3.4.2 Exclusion criteria

The following criteria were used to exclude participants from the study:

1. Patients who had bilateral femur fractures.
2. Re-occurrences of femur fractures.
3. Pathological fractures
4. Those with contralateral femur fractures that healed

3.5 Sample Size Determination

Objective one

To determine prevalence u the Kish Leslie formula was used based on the pilot study done at MNRH

$$N = \frac{Z^2_{\alpha/2} p(1-p)}{d^2}$$

Where:

N- required sample size,

Z- Z value (the standard normal deviate) corresponding to the desired confidence level, for 95% confidence, $Z \approx 1.96$, $Z \approx 1.96$)

d- Tolerable sampling error (precision) – 5% (0.05)

p- Estimated prevalence of the condition (0.187).

$$N = \frac{(1.96^2 \times 0.187) \times (1-0.187)}{0.05^2}$$

$$N = \frac{1.96^2 \times 0.152}{0.0025}$$

$$N = \frac{3.8416 \times 0.152}{0.0025}$$

$$N = 233.47 \sim 234$$

Estimated sample size was big for the estimated time frame and study population we used the scale down formula to estimate sample size.

$$S = \frac{N}{1 + \frac{N}{\text{population size}}}$$

S= adjusted sample size

$$N=234$$

$$P=180$$

$$S = \frac{234}{1 + \frac{234}{180}}$$

$$S=101$$

Objective two

The Fleiss formula (Fleiss, Levin, and Paik 2003) was used.

$$N = \frac{(Z_{\alpha} + Z_{\beta})^2 x [P1(1-P1) + P2(1-P2)]}{(P2-P1)^2}$$

Where: From the study of Rahul et al, and using pattern of fracture as the exposure variable

□ P1 = Proportion of LLD among patients with comminuted diaphyseal femur fractures = 21% (Rahul et al, 2014)

Assuming 15% difference i.e. those with simple fracture patterns, P2 will be

□ P2 = Proportion of LLD among patients with wage = 6%

□ $Z_{\alpha/2}$ = Z value for a two-sided test (typically 1.96 for a 95% confidence level)

□ Z_{β} = Z value for power (typically 0.84 for 80% power)

□ N = Required sample size for each group

Substituting into the above formula.

$$N = \{(1.96 + 0.84)^2 * [0.21(1- 0.21) + 0.06(1 - 0.06)]\} / (0.21 - 0.06)^2$$

$$N = \{7.84 * 0.2223\} / 0.0225$$

$$N = 77.5, \text{ rounded off to 78 participants.}$$

Therefore, the study enrolled 101 participants since it was the largest of the two calculated sample sizes.

3.6 Study variables

3.6.1 Dependent variables

LLD was the dependent variable in this study. It was measured using a CT-scanogram comparing the injured limb to the normal limb.

LLD was categorized as:

- Mild LLD: <2cm
- Moderate LLD: 2-5cm
- Severe LLD: >5cm

3.6.2 Independent variables

The independent variables in this study included patient factors such as age, sex, and comorbidities, as well as injury related factors such as the mechanism of injury (e.g., road traffic accident or fall), the pattern of the femur fracture classified as either simple with two fragments or complex with more than two fragments, surgical details (including the duration to surgery, entry point of the nail, retrograde Vs antegrade). Mid-thigh circumference was measured to determine the muscle bulk. Additional variables included pre-existing medical conditions that may affect healing or mobility, the presence of comorbidities (e.g., diabetes), all of which may influence the degree of leg length discrepancy (LLD) following intramedullary nailing (IMN) of femur fractures.

Age (years): The patient was asked their age which was then recorded. Age was categorized as follows; 18 to 29, 30 to 49, ≥ 50 . This categorization of age has been used in clinical studies and highlights the bimodal epidemiological distribution of femur shaft fractures.

Gender: This was recorded as reported, as male and female.

Marital status: This was recorded as either single, married or others which included being divorced and widowed.

Employment status: this was either urban or rural

Cause of Injury: this was the mechanism of injury of the fracture, and it included road traffic accidents.

Fracture classification: this was the broad classification of the fracture and was either closed or open fracture.

Pre-existing conditions: these were comorbidities the patients had and these included HIV, diabetes, hypertension.

Fracture pattern, and location: Was classified using the AO classification.

Injury related factors: included time from injury to surgery which was categorized as <1week, 1-2 weeks, 2-4weeks, 4-8weeks, more than 2 months but less than 6months.

Operating team: This included the team that conducted the surgery and this was categorized based on the 2 main people doing the surgery, Surgeon-resident, resident-resident, resident-others

Pre-operative traction: this was either yes or no and for the yes, we further categorized as either skin traction or skeletal traction.

Nail entry: this was either antegrade or retrograde nailing and the entry point which was specific for the antegrade as either piriformis or greater trochanter.

Locking mode: The stability offered by the nail was either static locking or dynamic locking.

Use of fluoroscopy and this was found out from the theatre notes, and this was either yes or no use of fluoroscopy

Mid-thigh circumference: This was measured on the normal thigh using a tape measure. The mid-thigh circumference was determined by first measuring from the greater trochanter to the superior pole of the patella and the middle of this length was determined, and the mid-thigh circumference was determined.

3.7 Sampling procedure

Consecutive sampling was used because the sample size and study population were finite and the estimated time frame of the study was short. Therefore, every subject meeting the inclusion criteria and available during the study period were selected until the required sample size was achieved.

- Each day during the study period, the PI or the research assistant visited the designated wards.
- Review of admission and surgical records to identify all patients who had undergone IMN for femur fractures. And then approach every patient who met the inclusion criteria.

3.7.1 Data collection methods and study procedure

Data collection followed a structured protocol, beginning with the identification of eligible participants in orthopedic wards at Mulago National Referral Hospital. Eligible adults aged 18 years and older who had undergone intramedullary nailing (IMN) for femur fractures and were on the first post-operative were approached for informed consent. Once consent was obtained, each participant completed a demographic and clinical questionnaire detailing their age, sex, employment status, mechanism of injury, and any pre-existing medical conditions. The pattern of injury was identified from the pre-operative x-ray by the PI

Following the initial interview, each participant underwent measurement of mid-thigh circumference of the normal limb using a tape measure.

The patient was then taken for the CT- scanogram as they went for the check x-ray

Recruitment of study participants

The duration of recruitment of the study participants was 5 months; it started in October 2025 following approval from the institutional review board (IRB – SOMREC) and administrative approval from MNRH and ended in February 2026 when the required sample size was attained.

The patients were recruited from the Orthopedic wards i.e. ward 7, trauma ward, and ward 3BA in MNRH. The research assistants reviewed the patients who had surgery of femur fractures with IMN identified patients who fulfilled the eligibility criteria of the study. The patients were

informed about the study and subjected to the study informed consent process. The participation in the study was entirely voluntary and patients who were free participant in the study were given the consent forms to sign.

Procedure of measuring LLD using the Ct- scanogram

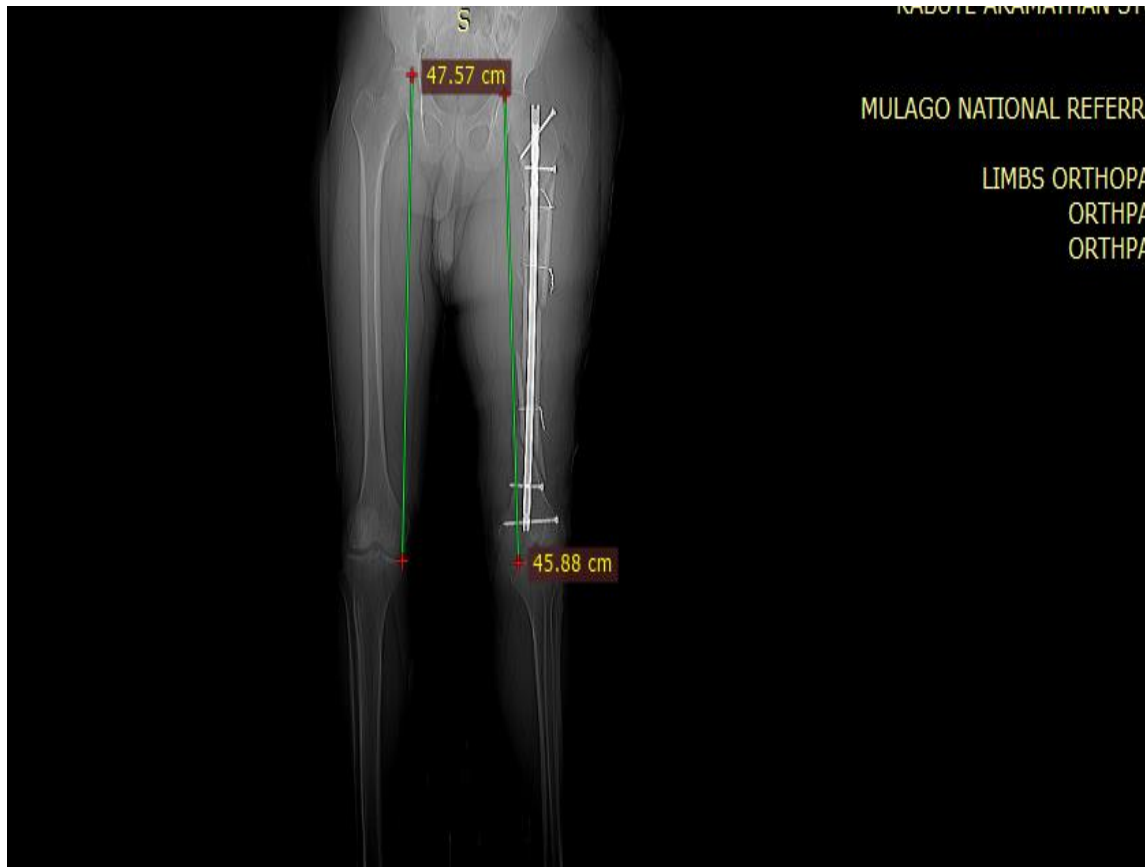
Step 1. The participant lay in a supine position and the hip stabilized on the examination table with the hip and knee in full extension.

Figure 1: Shows participant lying in a supine position and the hip stabilized on the examination table with the hip and knee in full extension



Step 2. CT-scanogram of the lower limbs from the pelvis to the ankle was performed with the participants in supine after which the femur length was measured using RadiAnt DICOM viewer from the center of the femur head to the medial femoral condyle by the radiologist.

Figure 2: Shows a CT-scanogram of the lower limbs from the pelvis to the ankle



Data was systematically documented and analyzed to identify associations between demographic, injury related factors, surgical related factors and the prevalence and severity of LLD.

3.8 Data management

The data collected was checked for completion by the PI

Study interview forms were checked to ensure there were no errors while the study participants could still be accessed.

Data dictionary was created before data collection; it included the description of study variables and the data management procedures

A database was set up using EPI- data version 4.4.1, the data was double entered.

After data entry, it was cleared and edited. The data was backed up on email and google drive.

3.9 Data analysis

Data was imported from EPI-data to STAT version 15 for windows. Descriptive statistics were conducted to provide a general description of the study participants. For numerical variables the summary statistics depend on the distribution of the data.

Normally distributed data was summoned by the mean and standard deviation, while median and interquartile range was used to summarize data which is not normally distributed.

Categorical variables were summarized with frequency and percentages.

Objective 1 To determine the prevalence of LLD: To describe the prevalence of LLD, descriptive statistical analysis of frequencies and percentages was used. LLD was defined as any measurable discrepancy (mild or moderate), expressed as a proportion of all participants with 95% confidence intervals following IMN of diaphyseal femur fractures.

Objective 2 I fit an ordinal logistic regression model at bivariable analysis and Variables with $p \leq 0.2$ in bivariate analysis and variables considered clinically important based on literature were included in the multivariable logistic regression model. From the fitted models, the proportional odds assumption was assessed using the generalized ordinal logistic regression with the autofit option and found that the assumption was not violated with no variable having P-value that was significant. In the result I present column percentages, Odds ratios and the associated probability values

3.10 Ethical considerations

Ethical approval was sought first from department of orthopedics of Makerere university School of Medicine Research and Ethics Committee (SOMREC) and Mulago Hospital's Institutional Review Board before initiation of data collection. Prioritizing participant autonomy and transparency, informed consent was meticulously secured. These measures, including obtaining ethical approval and informed consent, aimed to uphold the principles of beneficence, autonomy, and confidentiality, ensuring the ethical integrity of the research.

3.11 Dissemination of results

The results will be disseminated as follows

- Orthopedic department Makerere university college of health sciences
- Sir albert-cook library Makerere university and internal repository.
- School of postgraduate studies at Makerere university.
- School of medicine research and ethics committee.

CHAPTER FOUR

RESULTS

4.1 Description of Study Participants

Over a five-month recruitment period from October 2025 to February 2026, a total of **101 participants** with femur shaft fractures who had undergone intramedullary nailing (IMN) were enrolled at Mulago National Referral Hospital. All participants were assessed for limb length discrepancy (LLD) on the first post-operative day using a CT-scanogram. No participant was lost to follow-up, and the target sample size was fully achieved.

Primary outcome of the study was to determine the prevalence and factors associated with LLD following IMN of diaphyseal femur fractures among adults at MNRH.

4.1.1 Demographic Characteristics

The demographic characteristics of the 101 study participants are summarized in **Table 1**. The participants were predominantly young to middle-aged, with the largest proportion aged 30–49 years n=48 (47.5%), followed by those aged 18–29 years n=40 (39.6%). Participants aged 50 years and above constituted n=13 (12.9%) of the sample, the oldest participant was 71 years old reflecting the well-established epidemiological pattern of femur shaft fractures occurring predominantly in economically active adults.

Most of the participants were male, with 83 participants (82.2%) and only 18 (17.8%) females. This marked sex disparity is consistent with the higher exposure of males to road traffic accidents and occupational hazards in the Ugandan context. Regarding marital status, most participants were cohabiting i.e. those legally married and others just staying together (59.4%), followed by single participants (36.6%) and a small proportion in other categories including widowed or divorced (3.9%).

Table 1: Demographic characteristics of study participants

Characteristic	Frequency (n)	Percentage (%)
Overall	101	100
Age (years)		
18–29	40	39.6
30–49	48	47.5
≥50	13	12.9
Sex		
Male	83	82.2
Female	18	17.8
Marital Status		
Single	37	36.6
Cohabiting	60	59.4
Other (widowed/divorced)	4	3.9
Area of Residence		
Urban/Peri-Urban	65	64.4
Rural	36	35.6

4.1.2 Injury-Related Characteristics

The injury-related characteristics are presented in Table 2. Road traffic accidents (RTAs) n=89 (88.1%) was the dominant mechanism of injury.

Most of the fractures were closed n=81(80.2%). Comminuted fractures were the most prevalent pattern n=44 (43.6%).

Anatomically, fractures most involved mid-third of the femoral shaft n=65(64.4%). Delayed surgery defined as surgery beyond four weeks was observed in n=16 (15.8%) of participants. Majority of the operations were carried out by the resident-resident surgical team n=82 (81.2%)

Table 2: Injury-related and surgical characteristics of study participants

Variable	Category	Frequency (n)	Percentage (%)
Cause of Injury	Road traffic accident	89	88.1
	Fall	8	7.9
	Other	4	4.0
Nature of fracture	Open	20	19.8
	Closed	81	80.2
Fracture Pattern	Transverse(32A3)	34	33.7
	Oblique (32A2)	12	11.9
	Spiral (32A1)	11	10.9
	Comminuted(32B2,B3,C2,C3)	44	43.6
AO/OTA Classification	32A1	7	6.9
	32A2	16	15.8
	32A3	34	33.7
	32B2	14	13.9
	32B3	17	16.8
	32C2	4	4.0
	32C3	9	8.9
Location of Fracture	Proximal third	22	21.8
	Mid-third	65	64.4
	Distal third	14	13.9
Time from Injury to Surgery	< 1 week	13	12.9
	1–2 weeks	61	60.4
	2–4 weeks	11	10.9
	4–8 weeks	7	6.9
	> 8 weeks	9	8.9
Pre-operative Traction			
	Yes	74	73.3
	No	27	26.7
Pre-existing Comorbidities			
	Yes	15	14.9
	No	86	85.1
Use of fluoroscopy			
	Yes	15	14.9
	No	86	85.1

Table 3: Surgical Teams

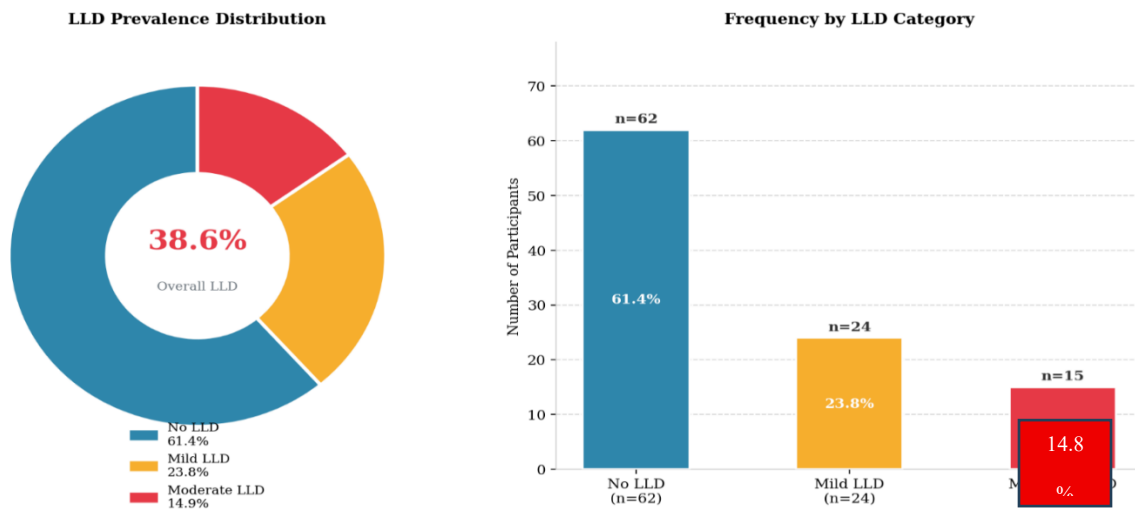
Surgical Team	None LLD	Mild LLD	Moderate LLD	Total
Surgeon-Resident	10(66.7)	2(13.33)	2(20)	15(14.9)
Resident-Resident	50(60.98)	20(24.39)	12(14.63)	82(81.2)
Resident-Others	2(50)	2(50)	0(0)	2(1.98)
Total	62(61.39)	24(23.76)	15(14.87)	101

4.2 Objective 1: Prevalence of Limb Length Discrepancy Following Intramedullary Nailing

Of the 101 participants assessed on the first post-operative day, 38.6% [95% CI (29.1,49.8)] had measurable limb length discrepancy following intramedullary nailing of femoral shaft fractures. Specifically, (23.8% [95% CI (15.9,33.3)]) had mild LLD (femoral length difference < 2 cm), and 15 participants (14.8% [95% CI (8.6,23.3)]) had moderate LLD (difference of 2–5 cm). Notably, no participant developed severe LLD (> 5 cm), The remaining 62 participants (61.4%) had no detectable LLD on CT-scanogram.

Figure 3: prevalence and severity of Limb Length Discrepancy following intramedullary nailing of femur fracture (N=101)

Figure 1: Prevalence and Severity of Limb Length Discrepancy Following Intramedullary Nailing of Femur Fractures (N=101)



4.3 Objective 2: Factors Associated with Severity of Limb Length Discrepancy

4.3.1 Bivariate Analysis

Bivariate analysis of factors associated with severity of limb length discrepancy showed that fracture-related factors showed the main associations of severe outcomes. Greater trochanter nail entry was associated with higher odds of worse LLD compared to piriformis entry (OR 2.15, 95% CI 1.11-4.16, $p=0.023$). Patients who did not receive pre-operative traction had higher odds of LLD than those with traction (OR 2.11, 95% CI 1.55-2.88, $p<0.001$). Similarly, dynamic locking was associated with lower odds of LLD compared to static locking (OR 0.18, 95% CI 0.08-0.40, $p<0.001$). Delays in surgery were strongly associated with LLD, with the greatest effect observed for surgery performed more than 1 month after injury (OR 84.0, 95% CI 21.73-324.64, $p<0.001$). However, the small numbers in the cells led to very wide confidence intervals. Fracture location was also significant (OR 0.25, 95% CI 0.11,0.59, $p 0.001$), as mid-third and distal fractures had lower odds of LLD compared to proximal fractures. Other factors, including age, sex, marital status, residence, cause of injury, use of C-arm, and pre-existing conditions, showed no significant associations in bivariate analysis. Bivariate ordinal logistic regression adjusted for clustering at the surgical team level, neither resident-resident teams (OR 1.23, 95% CI 0.36–3.58, $p=0.838$) nor resident-others (OR 1.27, 95% CI 0.50–1.67, $p=0.819$) showed a statistically significant difference in LLD severity compared to surgeon-resident teams as the reference category. (Table 4).

Table 4: Bivariate analysis of factors associated with severity of limb length discrepancy n(column%)

Characteristic	None n (%)	Mild n (%)	Moderate n (%)	OR (95% CI)	p-value
Overall	62 (61.4)	24 (23.8)	15 (14.9)	—	—
Age, mean (SD)	35.3 (14.6)	—	—	1.00 (0.97,1.04)	0.848
Sex					
Male	51 (61.4)	20 (24.1)	12 (14.5)	1	—
Female	11 (61.1)	4 (22.2)	3 (16.7)	1.01 (0.20,5.23)	0.987
Nail Entry Point					
Piriformis	39 (70.9)	12 (63.2)	5 (38.5)	1	—
Greater trochanter	16 (29.1)	7 (36.8)	8 (61.5)	2.15 (1.11,4.16)	0.023
Fracture pattern					
Transverse	30(48.4)	2(8.3)	2(13.3)	1	
Oblique	11(17.7)	0(0.0)	1(6.7)	0.71(0.47,1.06)	0.097
Spiral	5(8.1)	4(16.7)	2(13.3)	8.31(4.21,16.46)	<0.001
comminuted	15(24.2)	14(58.3)	5(33.3)	11.51(6.89,19.23)	<0.001
Pre-operative Traction					
Yes	49 (79.0)	17 (70.8)	8 (53.3)	1	—
No	13 (21.0)	7 (29.2)	7 (46.7)	2.11 (1.55,2.88)	< 0.001
Locking Mode					
Static locking	38 (61.3)	22 (91.7)	13 (86.7)	1	—
Dynamic locking	24 (38.7)	2 (8.3)	2 (13.3)	0.18 (0.08,0.40)	< 0.001
Time from Injury to Surgery					
< 1 week	12 (19.4)	0 (0.0)	1 (6.7)	1	—
1–2 weeks	48 (77.4)	12 (50.0)	1 (6.7)	3.25 (2.70,3.91)	< 0.001
2–4 weeks	0 (0.0)	8 (33.3)	3 (20.0)	—	—
> 4 weeks	2 (3.2)	4 (16.7)	10 (66.7)	84.00 (21.73,324.64)	< 0.001
Location of Fracture					
Proximal third	8 (12.9)	8 (33.3)	6 (40.0)	1	—
Mid-third	45 (72.6)	12 (50.0)	8 (53.3)	0.25 (0.11,0.59)	0.001
Distal third	9 (14.5)	4 (16.7)	1 (6.7)	0.32 (0.19,0.53)	< 0.001
C-arm Use					
Yes	7 (11.3)	4 (16.7)	4 (26.7)	1	—
No	55 (88.7)	20 (83.3)	11 (73.3)	0.49 (0.09,2.62)	0.407
Pre-existing Comorbidities					
Yes	9 (14.5)	3 (12.5)	3 (20.0)	1	—
No	53 (85.5)	21 (87.5)	12 (80.0)	0.93 (0.53,1.65)	0.815
Mid-thigh circumference (cm) Mean (SD)	47(5.5)	50.2(5.5)	50.13(3.90)	1.07(1.07,1.08)	<0.001
Surgical Team					
Surgeon-resident	10(66.67)	2(113.33)	3(20)	1	
Resident-resident	50(60.98)	20(24.39)	12(14.63)	1.12(0.35,3.5)	0.838
Resident-others	2(50)	2(50)	0(0)	1.27(0.16,9.91)	0.819

All ordinal logistic regression estimates have been adjusted for clustering at surgical team level

4.3.2 Multivariable Ordinal Logistic Regression

Ordinal logistic regression was the most appropriate model for this outcome structure, as it preserves the rank order information while providing a single interpretable OR representing the odds of being in a higher severity category.

Variables entered the multivariable model included those with $p \leq 0.2$ at bivariate analysis and clinically relevant factors. In multivariable ordinal logistic regression, several factors were independently associated with limb length discrepancy. Fracture pattern remained with strong association, comminuted fractures (aOR 13.62, 95% CI 2.14,86.74, $p=0.006$) associated with more Odds of LLD, while oblique fractures were not associated with LLD (aOR 0.71, 95% CI 0.36,1.39, $p=0.318$). Older age was slightly protective, with each additional year associated with lower odds of LLD (adjusted odds ratio [aOR] 0.97, 95% CI 0.94,0.99, $p=0.011$). Fracture location was independently significant (mid-third aOR 0.21; distal aOR 0.12, both $p<0.001$) after full adjustment, Mid-thigh circumference was independently and significantly associated with LLD severity in the multivariable model (aOR 1.11, 95% CI 1.07,1.14, $p<0.001$), Greater trochanter entry point had high odds of severe LLD (aOR 2.79, 95% CI 1.99,3.90, $p<0.001$), and absence of pre-operative traction was associated with higher odds of LLD (aOR 3.96, 95% CI 3.04,5.17, $p<0.001$). Locking method and use of a C-arm were not significantly associated with severity of LLD. (*Table 5*)

Table 5: Multivariable ordinal logistic regression — factors independently associated with severity of limb length discrepancy n(column %)

Characteristic	None n (%)	Mild n (%)	Moderate n (%)	aOR (95% CI)	p-value
Overall	62 (61.4)	24 (23.8)	15 (14.9)	—	—
Age (years)	—	—	—	0.97 (0.94,0.99)	0.011
Nail Entry Point					
Piriformis	39 (70.9)	12 (63.2)	5 (38.5)	1	—
Greater trochanter	16 (29.1)	7 (36.8)	8 (61.5)	2.79 (1.99,3.90)	< 0.001
Pre-operative Traction					
Yes	49 (79.0)	17 (70.8)	8 (53.3)	1	—
No	13 (21.0)	7 (29.2)	7 (46.7)	3.96 (3.04,5.17)	< 0.001
Fracture Pattern					
Transverse	30 (48.4)	2 (8.3)	2 (13.3)	1	—
Oblique	11 (17.7)	0 (0.0)	1 (6.7)	0.71 (0.36,1.39)	0.318
Spiral	5 (8.1)	4 (16.7)	2 (13.3)	6.59 (1.07,40.71)	0.043
Comminuted	15 (24.2)	14 (58.3)	5 (33.3)	13.62 (2.14,86.74)	0.006
Locking Mode					
Dynamic locking	24 (38.7)	2 (8.3)	2 (13.3)	1	—
Static locking	38 (61.3)	22 (91.7)	13 (86.7)	0.98 (0.20,4.76)	0.976
C-arm Use					
Yes	7 (11.3)	4 (16.7)	4 (26.7)	1	—
No	55 (88.7)	20 (83.3)	11 (73.3)	1.52 (0.34,6.70)	0.583
Location of Fracture					
proximal	8(12.9)	8(33.3)	6(40.0)	1	
Mid-third	45(72.6)	12(50.0)	8(53.3)	0.21(0.17,0.26)	<0.001
distal	9(14.5)	4(16.7)	1(6.7)	0.12(0.08,0.17)	<0.001
Mid-thigh circumference (cm), Mean(SD)	47(5.5)	50.2(5.5)	50.13(3.9)	1.11(1.07,1.14)	<0.001

aOR = adjusted odds ratio; CI = confidence interval

CHAPTER FIVE

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This study examined the prevalence of limb length discrepancy (LLD) and its associated factors among 101 adults with femoral shaft fractures treated by intramedullary nailing (IMN) at Mulago National Referral Hospital (MNRH) between October 2025 and February 2026. Limb length was assessed radiologically on the first post-operative day using CT-scanogram. The overall prevalence of LLD was 38.6%, with 24 (23.8%) having mild LLD and 15 (14.8%) having moderate LLD.

Comminuted fractures (aOR 13.62, 95% CI 2.14,86.74, $p=0.006$) and spiral fractures (aOR 6.59, 95% CI 1.07,40.71, $p=0.043$) were independently associated with LLD. Absence of pre-operative traction showed one of the strongest independent associations with LLD. (aOR 3.96, 95% CI 3.04,5.17, $p<0.001$).

5.1.1 Prevalence of Limb Length Discrepancy

The overall prevalence of LLD in this study was 38.6% ($n=39$), comprising 23.8% ($n=24$) mild LLD (< 2 cm) and 14.8% ($n=15$) moderate LLD (2–5 cm). No participant had severe LLD (> 5 cm) and 61.4% had no measurable discrepancy. This prevalence falls within the globally reported range of 20–43% following IMN of femoral shaft fractures (Hudson et al., 2019).

The observed prevalence is higher than the 18–21% reported in high-resource settings. Gheraibeh et al. (2018) in a quality improvement study at a Level 1 Trauma Centre found LLD > 1.5 cm in 21.4% of 98 consecutive patients with comminuted femoral fractures assessed by post-operative CT-scanogram. Kakadia et al. (2019) reported 18% in a large American multicenter cohort. The higher prevalence at MNRH likely reflects the combined effect of injury complexity due to road traffic accidents, which tend to produce high-energy, complex fracture patterns that are inherently more difficult to reduce and stabilize with precision. Also, resource limitations in fracture care such as limited access to intraoperative fluoroscopy, fracture tables, distraction devices (femoral distractor), and standardized traction resources recognized as adjuncts for accurate length restoration during IMN. (Ricci et al., 2009).

Regionally, the prevalence is close to the 35.3% reported by Phiri et al. (2018) following IMN in Zambia a sub-Saharan African setting with comparable resource constraints suggesting that the LLD burden reflects systematic challenges common to the region rather than institution-specific factors.

5.1.2 Demographic Characteristics

The participants were predominantly young to middle-aged. The largest age group was 30–49 years, comprising 47.5% of participants, followed by those aged 18–29 years at 39.6%. Participants aged 50 years and above constituted the smallest group at 12.9%. Collectively, 87.1% of participants were below 50 years of age at the time of surgery, consistent with the well-established epidemiological pattern in which femur shaft fractures predominantly affect economically active younger adults. This distribution reflects the high-energy trauma mechanism of road traffic injuries, which disproportionately affect young males in low and middle-income countries including Uganda (*Uganda Ministry of Health, 2021*). The number of working age adults in these participants is clinically significant, as LLD in this population has direct consequences for occupational function, household productivity, and long-term quality of life.

Majority were male (82.2%) and (17.8%) females. This sex distribution is consistent with findings from comparable sub-Saharan African studies. Phiri (2018) reported 83.5% male predominance in his Zambian cohort, and the pattern has been attributed to the higher exposure of males to road traffic accidents, motorcycle riding, and manual occupational hazards in the East African context (*Makhni et al., 2019*). The marked imbalance between male and female participants limits the statistical power to detect sex-specific differences in LLD outcomes, a limitation acknowledged in this study.

Most participants resided in urban or peri-urban areas 64.4%, with 35.6% from rural settings. This urban predominance reflects the catchment pattern of MNRH as Uganda's premier national referral hospital, which serves primarily the greater Kampala metropolitan area and receives referrals from across the country. The higher proportion of urban residents may also reflect better access to emergency transport and a shorter time from injury to hospital arrival compared to rural patients. However, rural patients, when they do arrive, often present after longer delays a factor that has implications for LLD risk through its association with delayed surgery (*Jayasuriya et al., 2016*).

5.1.3 Age and Limb Length Discrepancy

In the multivariable model, older age was independently and significantly associated with lower odds of LLD (aOR 0.97, 95% CI 0.94,0.99, $p=0.011$). Each additional year of age conferred a 3% reduction in the odds of worse LLD severity.

This is unexpected finding since older age is conventionally associated with osteoporosis and reduced bone quality likely reflects the fracture epidemiology of this study. Older patients sustained low energy mechanisms producing simpler fracture patterns such as transverse and short oblique) compared to the high-energy RTA patterns more common among younger patients. The study was predominantly young (86.1% under 50 years) and male (82.2%), which limits the range of age-related fracture pattern differences detectable. Haidukewych et al. (2018) described a bimodal distribution of femoral shaft fractures high energy in young patients versus lower energy insufficiency fractures in older patients with correspondingly different fracture complexities. Uganda Ministry of Health (2021) confirms that road traffic injuries, which characteristically produce high energy comminuted fractures, disproportionately affect young males in Uganda.

5.1.4 Sociodemographic Factors and Limb Length Discrepancy

Sex (OR 1.01, $p=0.987$), marital status ($p>0.4$ across categories), area of residence (OR 1.02, $p=0.943$), and cause of injury showed no statistically significant association with LLD severity in either bivariate or multivariable analysis.

The non-significant sex effect varies with literature suggesting that female sex may have higher LLD association due to differences in femoral morphology, muscle mass, and bone density (Makhni et al., 2019; Kim et al., 2019). However, the markedly skewed sex distribution (82.2% male; $n=18$ females) severely limits statistical power to detect sex-related differences, and firm conclusions cannot be drawn.

The non-association of area of residence with LLD is consistent with the understanding that residential location does not directly influence intraoperative fracture mechanics. However, residence may indirectly affect LLD risk through its association with surgical delay, as rural patients typically face greater transport and financial barriers to reaching national referral

facilities (Nyakaana et al., 2022; Jayasuriya et al., 2016). This pathway was likely captured in the bivariable model through the surgical delay variable.

The non-significance of cause of injury is unsurprising given that road traffic accidents accounted for 88.1% of cases, leaving insufficient variability to detect mechanism-specific effects. Robinson et al. (2018) note that mechanism of injury primarily influences LLD risk through its downstream effect on fracture pattern complexity rather than independently, consistent with the finding that fracture pattern not mechanism was the dominant predictor in the adjusted model.

5.1.5 Injury-Related Characteristics

Road traffic accidents were the predominant mechanism of injury, accounting for 88.1% of all femur shaft fractures in this study. Falls from height accounted for 7.9%, and the remaining 4.0% resulted from other mechanisms including assault and industrial injury. The dominance of RTAs as the primary mechanism is consistent with the established epidemiology of femoral shaft fractures in sub-Saharan Africa. Phiri (2018) reported RTAs in 83% of cases in Lusaka, and the Uganda Ministry of Health (2021) confirms that road traffic injuries are the leading cause of orthopaedic trauma admissions at national referral hospitals. High-energy RTA mechanisms are particularly important in the context of this study because they are strongly associated with comminuted and segmental fracture patterns, the fracture types most strongly linked to worse LLD outcomes in the multivariable analysis.

The fracture pattern distribution revealed a high burden of complex fractures in this study. Comminuted fractures were the most common pattern at 43.6%, followed by transverse fractures at 33.7%, oblique fractures at 11.9%, spiral fractures at 10.9%. The predominance of comminuted fractures almost half the cohort reflects the high-energy nature of the injuries. The Winqvist-Hansen classification of comminution, whereby higher grades of cortical comminution are directly associated with greater shortening risk, provides the biomechanical basis for this finding (Winqvist, Hansen, and Clawson, 1984), associated with greater comminution and worse length-restoration outcomes (Ricci et al., 2009).

The anatomical distribution of fractures showed that the mid-third of the femoral shaft was the most frequently involved location, accounting for 64.4% of cases. Proximal third fractures comprised 21.8% and distal third fractures 13.9%. This distribution reflects the well-recognized pattern in which the femoral diaphysis is most fractured at its mid-section, which is the narrowest and biomechanically most vulnerable portion of the shaft in high-energy trauma.

5.2 Factors associated with LLD

5.2.1 Fracture Pattern and Limb Length Discrepancy

Fracture pattern showed a strong independent association with LLD severity. Compared to transverse fractures, comminuted fractures (aOR 13.62, 95% CI 2.14,86.74, $p=0.006$) and spiral fractures (aOR 6.59, 95% CI 1.07,40.71, $p=0.043$) were independently associated with worse LLD. Oblique fractures were not significantly different from transverse fractures (aOR 0.71, $p=0.318$).

Winqvist, Hansen, and Clawson (1984), in their landmark series of 520 cases, demonstrated that higher grades of cortical comminution correlated directly with shortening and malrotation after closed IMN: Winqvist-Hansen types III and IV displayed LLD rates of 14.8% and 22.8% respectively. Their classification system remains fundamental to surgical decision-making in femoral shaft fractures (Ricci et al., 2009). Vaidya et al. (2012) found similar findings, demonstrating that all patients in their series with significant LLD following IMN had Winqvist-Hansen grade III or IV comminution. Gheraibeh et al. (2018) similarly advocated for routine post-operative CT-scanogram in comminuted cases, noting that visual and clinical intraoperative length assessment is unreliable in this subgroup.

The biomechanical explanation is that in comminuted fractures, loss of cortical buttressing between fragments removes the natural resistance to axial collapse of the nail within the medullary canal allowing the proximal and distal segments to telescope together under the shortening forces of the thigh musculature. They also present with bone loss, cortical disruption difficult in maintaining length during nailing. In the context of our study at MNRH, where intraoperative fluoroscopy was used in only 14.8% of cases, this telescoping may go unrecognized intraoperatively (Wheless, 2020). Petra et al. (2018) specifically identified comminuted and spiral patterns as the most technically demanding for length restoration in their

quality improvement initiative and recommended specific intraoperative length attainment techniques for these fracture types.

The significant association of spiral fractures with LLD (aOR 6.59) reflects the rotational instability of this pattern. Spiral fractures, produced by torsional or rotational forces, create long oblique fracture lines that can make reduction and length attainment difficult and generate an inherently unstable bone-nail construct thus increasing the chances of getting LLD. Koval and Zuckerman (2018) note that spiral femoral shaft fractures carry a tendency toward shortening under muscle tension that is underappreciated compared to comminuted fractures, particularly when reduction aids are unavailable.

5.2.2 Time from Injury to Surgery and Limb Length Discrepancy

Surgical delay demonstrated a strong relationship with LLD severity across all time categories in bivariate analysis. However, this was not in multivariate model because small numbers in cells destabilized the model. Compared to surgery within one week, surgery between one and two weeks carried significantly higher odds of LLD (OR 3.25, 95% CI 2.70,3.91, $p<0.001$), and surgery beyond four weeks was associated with worse outcomes (OR 84.00, 95% CI 21.73–324.64, $p<0.001$). Surgical delay remained one of the strongest independent predictors of LLD severity. The variable was not in multivariable model because the small numbers in cells destabilized the model

StatPearls (2023) documents that delayed surgery results in progressive soft tissue contracture, periosteal fibrosis at the fracture site, muscle shortening from prolonged spasm, and early fracture-site callus formation around mal-positioned fracture fragments, all of which increase the technical difficulty of accurate length restoration at the time of surgery (Ashock et al., 2010). Giannoudis et al. (2017) also highlighted that resource constraints in developing countries create delays that translate directly into worse fracture outcomes.

In the Ugandan context, Jayasuriya et al. (2016) identified financial barriers, implant unavailability, and initial recourse to traditional bone setters as the primary drivers of delayed surgical presentation in East African settings. At MNRH, only 12.9% of patients in this study underwent surgery within one week while 15.8% had surgery beyond four weeks, a pattern that mirrors the delay thus the LLD response observed in bivariate analysis. The wide confidence

intervals for the most delayed group (n=16) limit precision but do not diminish the clinical significance of this association. Reducing time to surgery is the single most impactful and actionable systemic intervention available to reduce the LLD burden at this institution (O'Brien et al., 2020).

5.2.3 Pre-operative Traction and Limb Length Discrepancy

Absence of pre-operative traction was independently associated with higher odds of LLD (aOR 3.96, 95% CI 3.04,5.17, $p<0.001$). Patients without pre-operative traction had nearly four times the odds of LLD compared to those who were on traction.

Pre-operative traction, whether skin or skeletal counteracts the shortening forces exerted by the thigh musculature via ligamentotaxis, maintains soft tissue length and balance around the fracture site, and facilitates a more anatomical resting position of the fracture fragments prior to surgery, thus simplifying intraoperative length restoration. StatPearls (2023) recognizes pre-operative traction as a key component of fracture stabilization. Koval and Zuckerman (2018) recommend traction as standard pre-operative management whenever definitive surgery is not immediately possible, because prolonged muscle shortening worsens reduction difficulty. Winqvist, Hansen, and Clawson (1984) specifically listed strong pre-operative traction as part of their routine management protocol, citing its role in soft tissue equilibration before nailing.

The published evidence specifically linking pre-operative traction to post-operative LLD reduction is limited. The near-fourfold increase in LLD odds with absent traction in the current study likely reflect an amplified compensatory role in our setting where intraoperative alternatives fracture tables and fluoroscopy are consistently not readily available. In such a context, pre-operative traction may substitute for the intraoperative length control tools such as traction tables that are standard in high-resource settings (Bistola et al., 2020).

5.2.4 Nail Entry Point and Limb Length Discrepancy

Greater trochanter nail entry was independently associated with high odds of LLD in bivariate analysis (OR 2.15, 95% CI 1.11,4.16, $p=0.023$) and multivariable analysis (aOR 2.79, 95% CI 1.99,3.90, $p<0.001$), compared to piriformis fossa entry.

The existing literature on this comparison does not establish clear superiority of either entry point. A systematic review and meta-analysis by Havet et al. (2017) found no statistically

significant difference in femoral shortening (≥ 10 mm) between greater trochanteric and piriformis entry approaches (RR = 0.6, 95% CI 0.16,1.98, $p=0.38$), though trochanteric entry reduced operative duration. Kumar et al. (2019), in a further systematic review, found that neither entry point demonstrated clear superiority across outcome measures including malunion, functional scores, and LLD

The association observed in this study likely reflects contextual factors at MNRH. The piriformis fossa is anatomically co-linear with the femoral shaft axis, providing a direct nail trajectory that inherently facilitates length control. In contrast, greater trochanter entry requires a proximal lateral-to-medial redirect in nail trajectory. This is a clinically important consideration. The literature is consistent that a standard straight femoral nail designed for piriformis fossa entry should not be inserted through the greater trochanter, as the non-collinear trajectory forces a lateral-to-medial redirect that generates eccentric reaming, medial cortex comminution of the proximal fragment, and varus malalignment (Wheless, 2020). Where greater trochanter entry is intended, the recommended implant is a nail with a proximal lateral bend commonly referred to as a trochanteric entry nail or lateral-bend nail specifically engineered to accommodate entry at the trochanteric tip while maintaining a trajectory co-linear with the femoral canal (Ostrum et al., 2005; Alzahrani et al., 2023). For fractures in the proximal third of the femoral diaphysis in particular, where the short proximal fragment is subject to the unopposed deforming forces of the iliopsoas, gluteus medius, and external rotators, a reconstruction or cephalo-medullary nail with proximal locking screws directed into the femoral head and neck is the recommended implant, as it neutralizes these deforming forces and prevents progressive varus collapse and shortening (Ricci et al., 2009; Springer Nature, 2023). When this correction is imprecisely executed particularly without routine fluoroscopic guidance it may result in suboptimal nail seating, varus malalignment of the proximal fragment, or unintended distraction at the fracture site and thus LLD (Wheless, 2020; Alzahrani et al., 2023). At MNRH, the nail predominantly used for femoral shaft fractures is the standard straight inter-locked intramedullary nail, which is designed for piriformis fossa entry. When this nail is inserted through the greater trochanter as occurred in many greater trochanter entry point cases in this study the mismatch between nail design and entry point creates a biomechanical environment that is inherently less conducive to accurate length and alignment restoration. Confounding by case complexity whereby greater trochanter

entry may have been selected for more challenging cases cannot be excluded, but the significant adjusted association warrants attention.

5.2.5 Locking Mode and Limb Length Discrepancy

Dynamic locking was associated with LLD in bivariate analysis (OR 0.18, 95% CI 0.08,0.40, $p<0.001$), but this association was not retained after multivariable adjustment (aOR 0.98, $p=0.976$), indicating that the apparent protective effect was confounded by fracture pattern.

This finding aligns with established surgical rationale. Dynamic locking allowing controlled axial compression by locking the dynamic slot in the nail proximal end is selectively used for stable fracture patterns where intact cortical contact promotes healing. Static locking rigidly fixing both ends is reserved for comminuted, unstable, and segmental fractures. Patients receiving dynamic locking therefore had inherently simpler fractures and lower baseline LLD risk. After adjusting for the fracture pattern, locking mode had no independent effect, which is consistent with the literature (Ricci et al., 2009; Schemitsch et al., 2019). The choice of locking mode in clinical practice is governed by the fracture stability requirements and not by LLD prevention strategy.

5.2.6 Location of Fracture and Limb Length Discrepancy

Fracture location was significantly associated with LLD severity in both bivariate and multivariable analysis. In bivariate analysis, compared to proximal third fractures, mid-third fractures (OR 0.25, 95% CI 0.11,0.59, $p=0.001$) and distal third fractures (OR 0.32, 95% CI 0.19,0.53, $p<0.001$) were associated with substantially lower odds of LLD. This association was retained and strengthened in the multivariable model: after adjusting for all other variables, mid-third fractures remained independently associated with markedly lower odds of worse LLD (aOR 0.21, 95% CI 0.17,0.26, $p<0.001$), as did distal third fractures (aOR 0.12, 95% CI 0.08,0.17, $p<0.001$), both compared to proximal third fractures as the reference category. These findings confirm that fracture location is an independent association of LLD severity.

In proximal femoral shaft fractures, the proximal fragment is subjected to powerful deforming muscle forces: the iliopsoas produces flexion and external rotation, while the hip abductors produce abduction, collectively displacing the proximal fragment in a predictable and technically challenging pattern. These forces must be actively overcome at the time of nailing to achieve

accurate length restoration. When they are not fully neutralized particularly in the absence of a fracture table or adequate intraoperative fluoroscopy, as was the case in 85.1% of procedures in this study the nail is inserted into a proximal fragment that remains shortened and malpositioned, resulting in LLD (StatPearls, 2023; Ricci et al., 2009). Wheelless (2020) specifically highlights that these deforming forces in proximal third fractures are the principal source of malalignment in femoral IMN when reduction aids are unavailable.

The implant used also may cause worsening of this vulnerability. The standard straight locked intramedullary nail, which is the nail predominantly available and used at MNRH, is designed for piriformis fossa entry and is co-linear with the femoral shaft axis. While appropriate for mid-shaft and distal fractures where the surrounding musculature is balanced and the proximal fragment long, this nail design is biomechanically suboptimal for proximal third femoral shaft fractures. For fractures in this zone, the literature recommends a reconstruction nail or cephalomedullary nail a nail with proximal locking screws directed into the femoral head and neck as the implant of choice, precisely because the additional proximal fixation neutralizes the deforming forces of the iliopsoas and hip abductors that act on the short proximal fragment and drive varus collapse and shortening (Ricci et al., 2009; Springer Nature, 2023). Where a reconstruction nail is unavailable, the use of blocking (Poller) screws placed lateral to the nail in the proximal fragment is recommended as an adjunct to prevent varus malalignment and the resultant LLD in this fracture zone (Krettek et al., 1999; Garnavos, 2021).

In contrast, mid-third and distal third fractures benefit from a more balanced surrounding musculature and a longer proximal fragment that provides a greater lever arm for intraoperative reduction and more stable nail seating. The surgeon has greater mechanical advantage in restoring length for these fracture locations, which translates directly into better LLD outcomes. Khalid et al. (2006) confirmed this pattern, finding that proximal shaft fractures had consistently worse length and alignment outcomes compared to mid and distal shaft injuries, attributing this to the magnitude and direction of deforming forces rather than to fracture pattern alone.

In our study 63.6% of all the proximal femur fractures were comminuted fractures and this could explain the higher odds of getting LLD amongst these patients

The independent significance of fracture location in the adjusted model with the adjusted Odds ratios for mid-third and distal fractures being even more protective than the crude Odds ratios suggests that controlling for fracture pattern and other surgical variables reveals a genuine, location-specific effect on LLD.

5.2.7 Intraoperative Fluoroscopy (C-arm) and Limb Length Discrepancy

Intraoperative C-arm fluoroscopy was used in only **14.9% (n=15)** of cases in this study a critically low rate reflecting the documented shortage of functional fluoroscopy at MNRH. Despite this, no statistically significant association between C-arm use and LLD severity was detected in either the bivariate (OR 0.49, p=0.407) or multivariable analysis (aOR 1.52, p=0.583).

This non-significant result must not be interpreted as evidence that fluoroscopy is unhelpful. The very low utilization rate (n=15) severely limits statistical power to detect a meaningful difference. Rahul et al. (2012) and Petra et al. (2018) both identified intraoperative fluoroscopic length assessment as a key modifiable factor in reducing post-operative LLD and recommended its routine use during femoral IMN. At MNRH, the limited use of intraoperative fluoroscopy represents a gap in surgical quality, where LLD risk is greatest (Bosse et al., 2020).

5.2.8 Mid-Thigh Circumference and Limb Length Discrepancy

Mid-thigh circumference was independently and significantly associated with LLD severity in the multivariable model (aOR 1.11, 95% CI 1.07,1.14, p<0.001), indicating that each additional centimetre of mid-thigh circumference was associated with an 11% increase in the odds of being in a higher LLD severity category after adjusting for all other variables. The mean mid-thigh circumference was 47.0 cm (SD 5.5) in the no-LLD group, 50.2 cm (SD 5.5) in the mild LLD group, and 50.1 cm (SD 3.9) in the moderate LLD group, with a consistent gradient between no-LLD and LLD groups. This estimate reflected in the narrow confidence interval of 1.07 to 1.14 strengthens confidence that this is a genuine independent association rather than a chance finding.

This is explained by the technical demands that increased soft tissue bulk places on femoral IMN. Greater thigh circumference impedes direct palpation of bony landmarks necessary for accurate nail entry point identification, obscures the relationship between the nail and fracture

fragments, and makes intraoperative clinical length assessment by comparison of limb contours unreliable. Tucker et al. (2007), in a multicenter study of IMN outcomes in obese versus non-obese patients, demonstrated that antegrade femoral nailing in patients with larger soft tissue envelopes required approximately 50% more operative time and 80% more fluoroscopy time, reflecting the substantially greater technical difficulty of achieving accurate reduction and fixation.

Giannoudis et al. (2017) and Haidukewych et al. (2018) both emphasize that body habitus is an underappreciated determinant of fixation quality in femoral fractures, with larger patients requiring modified approaches to nail entry, greater reliance on intraoperative imaging, and more deliberate intraoperative length verification techniques. In resource-constrained settings where these compensatory measures are unavailable, the effect of soft tissue bulk on LLD risk is likely amplified compared to high-resource environments, which may explain why mid-thigh circumference emerged as a strong independent predictor in this cohort.

5.3 Study Strengths and Limitations

This study has several important strengths. It is among the first cross-sectional analytical study in Uganda to systematically measure LLD following IMN using CT-scanogram the recognized gold standard for post-operative limb length assessment (Martin et al., 2012; Sabharwal, 2006; Michael et al., 2005). The use of a standardized measurement protocol on a defined post-operative day reduces variability and enhances comparability with other studies.

Consecutive sampling minimized selection bias.

The use of ordinal logistic regression appropriately respected the ordered three-category LLD outcome, as recommended for this type of data (Bistola et al., 2020).

Limitations

- Cross-sectional study design limiting causal inference.
- As a single-center study design, findings may not generalize to other Ugandan hospitals with different resource profiles.
- The small group sizes of participants produced wide confidence intervals.

5.4 Conclusions

- This study found a clinically significant prevalence of LLD of 38.6% among adults undergoing intramedullary nailing for femoral shaft fractures at MNRH.
- The majority had mild (23.8%) LLD, and those with moderate were 14.8%. No participant had severe LLD on post-operative day one.
- The strongest independently associated variables with higher odds of worse LLD were comminuted fracture pattern, proximal fractures, increased mid-thigh circumference absence of pre-operative traction and surgical delay. Also, Greater trochanter entry point showed significant association with LLD
- C-arm utilization rate was 14.9%.
- Sociodemographic variables, locking mode, and C-arm use were not independently associated with LLD in the adjusted model.

5.5 Recommendations

- MNRH administration and the Ministry of Health should prioritize reducing time from injury to surgical fixation through consistent implant availability, theatre capacity expansion, and subsidized implant access schemes to address the financial barriers driving delayed presentation (Jayasuriya et al., 2016; Giannoudis et al., 2017).
- Functional intraoperative image intensifiers (C-arms) should be aimed for given that only 14.9% of current IMN cases utilize fluoroscopy.
- Sensitization of the community and patients about the need of operation for femur fractures so that they desist from seeking alternative care which causes delayed presentation.
- Use of devices such as femoral distractors and traction tables should be adopted to reduce the occurrence of LLD.
- Objective intraoperative length assessment e.g. using methods like comparison with the contralateral limb and use of diathermy pencil cable.

- Pre-operative skeletal or skin traction should be standardized for all patients awaiting IMN, given the near-fourfold increase in LLD risk with its absence and skeletal traction for those who delay more than 4 weeks
- Future prospective studies should follow patients beyond the first post-operative day to document LLD evolution during fracture consolidation and assess functional outcomes

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APPENDICES

APPENDIX 1: WORK PLAN

Schedule	Feb 2025	Mar 2025	April 2025	May 2025	Jun 2025	Aug 2025	Oct 2025	Nov 2025	Jan 2026	Feb 2026	June 2026	June 2026
Concept and proposal development												
proposal presentation												
Submission to SOMREC												
Approval from SOMREC												
Data collection												
Data analysis and write up												
Submission of dissertation to school												
Dissertation Defense												
Submission of final book to graduate school												
Manuscript writing and submission												

APPENDIX II: BUDGET

STATIONERY, AIRTIME AND PRINTING					
	Particulars	Unit of measure	Quantity required	Unit cost	Total Amount (Ugx)
1	Printing cost	Lump sum	1	300,000	300,000
2	Box file	Piece	2	30,000	60,000
3	Airtime	Lump sum	1	150,000	150,000
				Sub-total	510,000
HUMAN RESOURCES & EQUIPEMENT					
	Particulars	Unit of measure	Quantity required	Unit cost	Total Amount (Ugx)
1	Tape measure	piece	1	2,000	2,000
2	CT scanogram	person	100	20,000	2,000,000
3	Research Assistant	Person	2	750,000	1,500,000
4	Statistician	Person	1	800,000	800,000
				Sub-total	4,302,000
REFRESHMENTS AND TRANSPORT REFUND					
	Particulars	Unit of measure	Quantity required	Unit cost	Total Amount (Ugx)
1	Refreshments	Pack	100	5,000	500,000
2	Compensation for participants	person	100	10,000	1,000,000
3	Miscellaneous	Lump sum	1	500,000	500,000
				Sub-total	2,120,000
			GRAND TOTAL		7,293,000

Justification of the Budget

The costs will be incurred on printing and photocopying of the research proposal and dissertation including binding. Other costs include internet services for communication and accessing publications and other online literature.

Airtime will be required for communication and coordination with supervisors and the biostatistician.

Fixed costs

The fixed costs include.

- i. The biostatistician's professional fee.
- ii. Research assistants' fees
- iii. CT scanogram fees

Source of funding

This study was funded by the principal investigator.

**APPENDIX III: DATA COLLECTION TOOL: QUESTIONNAIRE AND CLINICAL
ASSESSMENT FORM**

Section A: Demographics

Data Extraction Form (For Medical Records)

Patient Information

I. **Questionnaire NO.:** _____

1. **Patient Information**

- Age: _____ years
- Gender: Male Female

2. **Sociodemographic Factors**

- Marital Status: Single Married Other
- Employment status: Urban Rural

Section B: Clinical History

1. **Details of injury**

- Cause of Injury:
 - Road Traffic Accident
 - Fall
 - Other (Specify): _____
- Fracture classification Open Closed
- Pre-existing conditions (e.g., diabetes, HIV): Yes No
 - If yes, specify: _____

2. Imaging Findings(pre-operative)

2.1 Fracture Pattern:

- Transverse
- Oblique
- Spiral
- Comminuted

AO classification

AO/OTA Classification	32A1	
	32A2	
	32A3	
	32B2	
	32B3	
	32C2	
	32C3	

3. Location of fracture

- proximal
- mid-third
- distal-third

Section C Treatment History

1. Time from Injury to Surgery:

- < 1week
- 1-2 weeks
- 2-4 weeks
- 4-8 weeks
- > 2 months

2. Pre-operative Traction

Yes No

2.1 If Yes (specify)

Skin Traction

Skeletal traction

3 Operating team

- Surgeon-resident
- Resident-resident
- Resident-others

4.1 Nail entry point

Piriformis

Greater trochanter:

4.2 Nail entry

Ante-grade

Retrograde

5 Locking mode

Static locking

Dynamic locking

6 Use of C-arm

Yes

No

Section D: Limb Length Assessment

1. Radiological Measurements

- Measurement from the center of the superior aspect of the femur head to the most distal part of the medial condyle.
 - Right: _____ mm
 - Left: _____ mm

2. Discrepancy

- Calculated Limb Length Discrepancy: _____ mm

Section E MID-THIGH CIRCUMFERENCE (of the un-injured limb)

(cm): _____

Instructions for Data Collectors

1. Ensure consent is obtained from each participant before collecting data.
2. Maintain confidentiality by anonymizing identifiable information.
3. Document all findings accurately and comprehensively.

Would you like to customize this tool further or focus on specific sections?

APPENDIX IV: ENGLISH VERSION CONSENT FORM.

Participant Identification Number.....

Title of the proposed study: Prevalence of Limb Length Discrepancy and Its Associated Factors After Intramedullary Nailing of Femur Fractures Among Adults at Mulago National Referral Hospital

Investigators: Name	Contact	Institution
1. Dr. Kasirye Ronald (Principal Investigator)	0703355582	Makerere University College of Health Sciences

Background and rationale for the study: limb length discrepancy after operation and use of implant which is a nail in femur fractures is a complication occurring in varying degrees of severity leading to complications such as scoliosis and osteoarthritis in patients. Despite use of this implant giving excellent results complications such as limb length discrepancy still occur. This study aims to evaluate the extent of LLD and highlight the need for prioritizing the acquisition of appropriate equipment to minimize LLD during surgery. The findings may serve as a foundation for developing future management protocols for LLD and provide valuable insights to guide further research in this area. By addressing these gaps, the study seeks to enhance both surgical practices and long-term care for patients.

Sponsors: Self (Dr. Kasirye Ronald)

Purpose: To establish the prevalence of leg length discrepancy (LLD) and identify the factors associated with LLD following intramedullary nailing (IMN) of femur fractures among adults at Mulago National Referral Hospital.

Estimated duration the research participant will take in the research project

You will be identified by the research assistant on the ward and will be found on the post-operative bed. An informed consent will be sought and then you will be taken through an interview to fill in the questionnaire. This will take about 30 minutes. The mid- thigh circumference will then be measured using the normal leg and this will take about 5 minutes. You will then be taken to the radiology department as you go for the Check X-ray, the CT-

Scanogram which will also be done which will last about 1 hour. You will therefore spend at most two (2) hours in the project.

Procedures:

Permission to conduct the study will be sought from the ward in-charges i.e. of Ward 7, Trauma ward, and ward 3B arthroplasty. If you meet the eligibility criteria, you will be enrolled and a face-to-face interview will be conducted and limb measurements and BMI will be done.

Who will participate in the study:

Patients who are 18 years and have had femur fractures managed with intramedullary nailing and are on the first post-operative day at MNRH, and consent to the study and these are estimated to be 102 participants.

Risks/discomforts:

In terms of risks and discomforts, it is anticipated that real limb length measurements conducted to determine the severity of LLD may involve some discomfort, in case patient has knee stiff and is required to fully extend their knee.

There is a risk of ionizing radiation which can damage DNA. However, in this study using the CT- scanogram uses less radiation compared to the conventional CT-Scan

Benefits:

The findings of this study will be disseminated to the Department of Orthopaedics of Makerere University College of Health Sciences; Albert Cook Medical Library and the Directorate of Research and Graduate Training. Your participation in the study will enable the researcher to achieve an academic milestone.

If you are found with significant LLD, you will be referred to the surgeon who will decide regards your management and if you require surgical intervention, you will be prepared for surgery and those who don't need will be referred to the orthopedic workshop for the shoe rise.

Confidentiality:

All the Information you give will be treated with the utmost confidentiality. Therefore, your name and other personal information is not required for the study. Further, access to the data collection tools will be limited to only the research team members, the School Of Medicine Research and Ethics Committee and the Uganda National Council for Science and Technology since these bodies are responsible for research in the country. The researcher will endeavor to see that summarizing the findings of the study is done in such a way that doesn't reveal specific identifiers of the study respondents.

Alternatives:

You are under no obligation to participate in this study. You should only participate if you are interested.

Cost of being a participant: You will not incur any costs as a result of your participation in this study.

NB: The participant shall incur the cost of the routine check x-ray as a requirement from the operating team to check for position of the IMN and the locking screws.

Compensation for participation in the study:

The researcher will afford a humble compensation worth 10,000/- (Ten thousand shillings only) since you will be required to spend a good amount of time participating in the study and a refreshment of 5000/- which will total up to 15000/- which will be given to you in cash from the research assistant.

Questions about the study

If you have any questions about this study, you may ask now or later by contacting the principal investigator (Dr. Kasirye Ronald) on mobile numbers +256703355582.

Questions about the rights of the study participants

For any inquiries regarding participants' rights or further clarification about participation in the study, please contact Prof. Ponsiano Ocama, the Chairperson of the School of Medicine Research and Ethics Committee (SOM-REC), on mobile number +256 772 421 190.

Statement of voluntariness

It is important to note that participation in the study is entirely voluntary, and there is no compulsion to take part. You are free to make your own decision about whether to participate in the study.

Dissemination of results

The study participants will get feedback of the findings and progress of the study. Any new information affecting the study or data with clinical relevance to research participants including incidental findings will be available to the participants and health care providers.

Ethical approval

This research has been approved by the Makerere University School of Medicine Research and Ethics Committee

STATEMENT OF CONSENT

..... thoroughly informed me about the procedures, risks, benefits, and my rights pertaining to this study by the researcher. I acknowledge that my choice to participate will not affect my regular medical care. I understand that my identity will be kept confidential when using this information. I am fully aware that I can withdraw my participation at any point. By signing this document, I do not relinquish any of my legal rights; rather, I affirm that I have been briefed on the research study and am voluntarily choosing to take part. All my queries and apprehensions have been satisfactorily addressed. I will be given a copy of this form for my records

Name.....

Signature/thumbprint of participant.....Date

Name.....

Signature of witness (if applicable)Date.....

Name.....

Signature of interviewer/Person obtaining informed consent

Date

APPENDIX V: LUGANDA VERSION CONSENT FORM.

Ekyokubiri IV. Endagaano mu Lunganda

Ennamba y'Oyo eyetabye mukunonyereza:

Omuttwe Gw'Okunonyereza Okugendererwa:

Enjawulo mu Buwanvu bw'Ebigere n'Ensonga Ezikwata Ku Gwo Oluvannyuma lw'Okuteekamu Intramedullary Nailing mu Kibegabega ky'Omugulu mu bantu abakulu mu Mulago National Referral Hospital

Abanoonyereza:

Erinnya | Essimu | Ekifo

1. Dr. Kasirye Ronald (Omunoonyereza Omukulu)

0703355582 | Makerere University College of Health Sciences

Ensibuko n'Enteekateeka y'Okunonyereza:

Okubeerawo kw'enjawulo mu buwanvu bw'ebigere oluvannyuma lw'okuteekamu **ekyuma** mu kibegabega ky'omugulu kye kimu ku bizibu ebivaamu ebizibu nga **scoliosis** ne **okugwelera kwa kabenuu** mu balwadde. Newankubadde **ekyuuma** kitwala eby'okujjanjaba mu maaso obulungi, okubaawo kw'enjawulo mu buwanvu bw'ebigere kikyali kizibu. Okunonyereza kuno kuleetedwa okwekeneenya obunene bw'enjawulo enetaagisa okukolebwako enkyukakyuka era kulaga obukulu bw'okufunira ebyuma ebisaanidde okumalawo enjawulo eno mu kutereeza ebuzibu buno. Ebikolebwa mu kunonyereza kuno bisobola okufuuka entandikwa y'enkola ez'enkizo mu kujjanjaba enjawulo eno era bisobola okuwa amagezi ag'omugaso mu kunonyereza okw'omu maaso.

Omuwagizi: Eby'ensimbi bikolebwako : Dr. Kasirye Ronald.

Ekigendererwa:

Okuzuula obungi bw'abantu abalina enjawulo mu buwanvu bw'ebigere (LLD) era n'okukebeza ensonga ezivaako enjawulo eno oluvannyuma lw'**Intramedullary Nailing (IMN)** mu **Mulago National Referral Hospital**.

Obude eyetabye mukunonyereza Bw'alitwala mu Kunoonyereza

1. Omulwadde gwebanaba bamaliliza okulongosa egumba lyekisambi e Mulago anaatuukirirwa ekibinja ky'okusoma era alabibwenga atukiridde okwetaba mukunonyereza kuno o'lwo ojja kuyisibwamu nkungeri okunonyerenza wekugenda okukolwebwa no mugaso gwako o'lyo wonakiriza ojja kusa omukono kundagano eno. Kino kijja kutwala eddakiika **30**.
2. Olwo omulwadde ajja kubuzibwa ebibuzo ebikwatagana nobuvune buno o'lyo onakeberegwa, n'okufuna obunene bwekisambi kyo okufuna ekigero ekijja kutwala eddakiika **30**.
3. Oluvanyuma, omulwadde ajja kutwalibwa mu **Radiology Department** okufuna **CT-Scanogram**, ekijja kutwala essaawa **1 kino kijjakolwebwa wamu ne'kifananyi kya xray ekyomulwadde ateledwamu ekyuma**.
4. Kyokka omulwadde ajja kumala essaawa **bbiri (2)** mu nteekateeka y'okusoma kuno.

Enkola y'Okunoonyereza

- Ebikwata ku balwadde okuva mu **Ward 7, Trauma Wards**, ne **3B Arthroplasty** bijja kutunulwamu oluvannyuma lw'okufuna olukusa okuva mu bagwira b'ebyallo.
- Abalwadde abakulu abameenyeka egumba lye kisambi mu kugulu era abajjanjabwa ne **IMN** nga bakulongosebwa kulunaku olusoka
- Ebibuzo bijja kubabuuzibwa ng'embeera yaabwe egobererwa, era ebigero by'ebigere byabwe bijja kukeberegwa wamu ne size ye kisambi.

Ani Ajja Kwetaba mu Kunoonyereza?

- Abalwadde abalina emyaka **18 oba egisingawo**.
- Abalwadde abajjanjabwa ne **Intramedullary Nailing** mu kibegabega ky'omugulu
- Abalwadde abaweddeyo nga bamaze olunaku lumu oluvannyuma lw'okujjanjabibwa. Abalwadde abakiriza okwetaba mu kunoonyereza kuno.

Obulabe Obusoboka

- Okukeberegwa kw'enjawulo mu buwanvu bw'omugulu kuyinza okuviirako obulumi butono mu balwadde nabalina amavivi agakakanyadde.
- Okukoze CT-scan kuliko obulabe olwensonga nti amasanyaraze gasobola okosa endagabutondde

Ebintu Ebirungi Ebinasinzirwako

- Ebikozesebwa mu kunoonyereza kuno bijja kuweerezebwa **Makerere University College of Health Sciences, Albert Cook Medical Library, n'Eggye ly'Okunoonyereza n'Obwassa obw'ensoma.**
- Abalwadde abazuulibwa nga balina enjawulo ennene bajja kuwerebwa e'wa **Orthopedic Consultant** alina obumanyirivu mu kujjanjaba abalwadde asalewo ekyo bakolera.
- Abalwadde abasobola okuwebwa obwongenza kubuwanvu bwamagulu bajja kuwrezebwa mu Orthopedic **Workshop.**

Obukuumi Bw'Ebyama

- Amawulire gonna goowa g'akwatibwako mu ngeri ey'ekyama.
- Ennyingo z'okunoonyereza zinakwatibwa abantu boka abakirizibwa (**abanoonyereza, ekitongole ky'eby'eddagala n'eggye ly'ensi ly'okusoma n'eby'ettendo mu Uganda**).
- Ebikozesebwa mu kunoonyereza bijja kuzaalibwa nga tebikuli mu muntu yenna.

Obusobozi Bw'Okusalawo

- Tewali muntu agula mulwadde kubeera kitundu mu kunoonyereza kuno.
- Omuntu yena akirizibwa Okusalawo okwe taba mukunonyereza oba okugana okwetaba mukunonyereza kuno.

Eby'ensimbi

- Omulwadde tasasula nsimbi yonna okugattibwa mu kunoonyereza kuno.
- Era omunonyereza yajja okusasulira CT. scanogram ejja okukolebwa

- Omulwadde akakirizibwa okwegatta mukunonyereza ajja kuwebwayo ensako ya 10,000/- ne 5000/- ezebwo kuywa omugatte gwa 15,000/-

Ebibuuzo Ebikwata ku Kunoonyereza

- Oyinza okubuuza ebibuuzo ebikwata ku kunoonyereza nga oyita **Dr. Kasirye Ronald** ku +256703355582.

Ebibuuzo ku Ddembe Ly'Oyo eyetabye mukunonyereza

- Oyinza okukubira **Prof. Ponsiano Ocama**, Ssentebe wa School of Medicine Research and Ethics Committee (SOM-REC) ku +256772421190. Bwonabera nekibuzo kyona ekikwatagana nedembe lyo mukunonyereza kuno.

OKKUKIRIZIBWA:

Okunoonyereza kuno kukkiriziddwa akakiiko akakulira okunoonyereza mu ssettendekero ly'abasawo aka School of Medicine Research and Ethics Committee (SOM-REC)

Okukkiriza Okwetaba mu Kunoonyereza

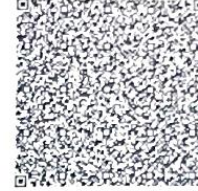
Nnazeemu okutegezebwa ebikwata ku kunoonyereza kuno era mpadde olukusa lwange. Ntegedde nti nze mpadde olukusa lwange nze kenyini.

.....
Erinnya ly'oyo eyetabye mu kunoonyereza	Omukono oba ekinkumu	Ennaku ez'omwezi
.....
Erinnya ly'oyo mujuliizi(bwekibakyetagisiza)	Omukono	Ennaku ez'omwezi
.....
Erinnya ly,omubuuza	Omukono gw'omubuuza	Ennaku ez'omwezi

APPENDIX VI: ETHICAL APPROVAL LETTER



23/09/2025
To: KASIRYE RONALD
makerereuniversityschoolofmedicine



Review Type: Initial Review

Re: Mak-SOMREC-2025-614: PREVALENCE OF LIMB LENGTH DISCREPANCY AND ITS ASSOCIATED FACTORS FOLLOWING INTRAMEDULLARY NAILING OF FEMUR FRACTURES IN ADULTS AT MULAGO NATIONAL REFERRAL HOSPITAL

I am pleased to inform you that at the 207 convened meeting on 09/09/2025, the MAK School of Medicine REC (Mak-SOMREC) meeting voted to approve the above referenced application. Approval of the research is for the period of 23/09/2025 to 23/09/2026.

As Principal Investigator of the research, you are responsible for fulfilling the following requirements of approval:

1. All co-investigators must be kept informed of the status of the research.
2. Changes, amendments, and addenda to the protocol or the consent form must be submitted to the REC for re-review and approval **prior** to the activation of the changes.
3. Reports of unanticipated problems involving risks to participants or any new information which could change the risk benefit: ratio must be submitted to the REC.
4. Only approved consent forms are to be used in the enrollment of participants. All consent forms signed by participants and/or witnesses should be retained on file. The REC may conduct audits of all study records, and consent documentation may be part of such audits.
5. Continuing review application must be submitted to the REC **eight weeks** prior to the expiration date of **23/09/2026** in order to continue the study beyond the approved period. Failure to submit a continuing review application in a timely fashion may result in suspension or termination of the study.
6. The REC application number assigned to the research should be cited in any correspondence with the REC of record.
7. You are required to register the research protocol with the Uganda National Council for Science and Technology (UNCST) for final clearance to undertake the study in Uganda.

The following is the list of all documents approved in this application by MAK School of Medicine REC (Mak-SOMREC):

No.	Document Title	Language	Version Number	Version Date
1	WORK PLAN 2	ENGLISH	PDF	2025-09-17
2	INFORMED CONSENT 2	ENGLISH	PDF	2025-09-17

3	PROTOL WITH ACCEPTED TRACK CHANGES	ENGLISH	PDF	2025-09-17
4	Translated consent	ENGLISH	PDF	2025-09-17
5	Data collection tools	ENGLISH	PDF	2025-06-29
6	COVID-19 & EBOLA risk management plan	ENGLISH	PDF	2025-06-29
7	Community Engagement plan	ENGLISH	PDF	2025-06-29

Yours sincerely,




Prof. Ponsiano Ocuma

For: MAK School of Medicine REC (Mak-SOMREC)

APPENDIX VII: ADMINISTRATIVE CLEARANCE FROM MULAGO NATIONAL REFERRAL HOSPITAL

TELEPHONE: +256-41554008/1
FAX: +256-414-5325591
E-mail: admin@mulago.or.ug
Website: www.mulago.or.ug



MULAGO NATIONAL REFERRAL HOSPITAL
P. O. Box 7051
KAMPALA, UGANDA

IN ANY CORRESPONDENCE ON THIS
SUBJECT PLEASE QUOTE NO.....

20th October 2025.

Dr. Kasirye Ronald
Principal Investigator
Department of Orthopedic Surgery
Makerere University

Dear Dr. Kasirye,

RE: ADMINISTRATIVE CLEARANCE TO CONDUCT A STUDY AT MULAGO NATIONAL REFERRAL HOSPITAL.

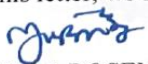
The Mulago Hospital Management is pleased to inform you that you have been offered clearance to conduct the study titled **MHREC 3028: “Prevalence of Limb Length Discrepancy and its associated factors following Intramedullary Nailing of Femur Fractures in adults at Mulago National Referral Hospital”**.

The above clearance is granted to you on the following conditions;

- That you will follow the research ethical processes
- Agreed to comply with all institutional policies and regulations of Mulago National Referral Hospital
- Agreed to provide end of study report and acknowledge Mulago hospital in all publications
- Submit a copy of filled in participant compensation log after recruiting one quarter of the approved research sample size.

Administrative clearance is valid for one (1) year effective from 15th October 2025 to 14th October 2026.

By copy of this letter, we reiterate our commitment to support this study.


DR. BYANYIMA ROSEMARY
EXECUTIVE DIRECTOR
MULAGO NATIONAL REFERRAL HOSPITAL

Copied to;

1. Incharge – Orthopedic department

Vision: “To be the leading centre of Health Care Services”